A STUDY OF THE RELATIONSHIP BETWEEN OCEANIC CHEMICAL MESOSCALE AND SEA SURFACE THERMAL STRUCTURE AS DETECTED BY SATELLITE INFRARED IMAGERY

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Monterey, California

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A Study of the Relationship
Between Oceanic Chemical Mesoscale and
Sea Surface Thermal Structure as Detected
by Satellite Infrared Imagery

by

Don Alan Nestor

June 1979

Thesis Advisor: E.D. Traganza

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A Study of the Relationship Between Oceanic Chemical Mesoscale and Sea Surface Thermal Structure as Detected by Satellite Infrared Imagery

by

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Lieutenant, United States Navy
B.S., United States Naval Academy, 1972

Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

In recent years the study of ocean fronts and eddies has become increasingly important to the U.S. Navy for they are of vital importance in understanding underwater sound transmission. From the history of satellite pictures for the area of the ocean off the central California coast, it appears that cold water which has come to the surface as a result of upwelling has become intertwined within the California Current. The persistent thermal features in the sea surface which are formed were the subject area of this study. Direct telephone contact was established with the satellite receiving station which afforded real time satellite information as to the thermal structure of the sea surface on a mesoscale. This satellite sensed thermal structure was then compared with _in situ_ nutrient and temperature data collected on three separate cruises on board the research vessel ACANIA. A strong inverse correlation was observed between nutrient concentrations and sea surface temperature in the case of a recent upwelling. The nitrate to phosphate ratio ranged fron 1.9:1 to 12.4:1 in this study with the highest values observed in the upwelled waters, and a overall modal value of 5:1 observed in the open ocean waters. The agreement between the _in situ_ data and the satellite imagery was very strong and the utilization of satellite imagery was shown to be a very effective method to localize an ocean front.

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INTRODUCTION

In recent years the study of ocean fronts and eddies has become increasingly important to the U.S. Navy for they are of vital importance in understanding both short and long range underwater sound transmission. From a naval warfare standpoint an ocean front can be defined as "any discontinuity in the ocean which significantly alters the pattern of sound transmission and propagation loss" (Cheney and Winfrey, 1974). For this study the fronts and eddies associated with the coastal upwelling ecosystem off the Central California coast were investigated from a chemical mesoscale standpoint utilizing satellite infrared imagery to detect the presence of the features. The significance of the nutrient concentrations and their changes associated with ocean fronts and eddies is that the larger values of nutrients normally observed with upwelled water can lead to increased biological activity which is generally found along a front. An increase in biological activity can have a significant degrading effect on Antisubmarine Warfare (ASW) operations due to the associated increase in reverberation and ambient noise (Cheney and Winfrey, 1974). Therefore, studying the change in the concentrations of the nutrients across oceanic thermal boundaries is an important step in gaining a better understanding of the characteristics of ocean fronts.

The concentrations of nitrate and phosphate in seawater have been extensively studied for many years. From these

studies it can be summarized that the nitrate and phosphate concentrations of the world's oceans are quite varied, especially in the boundary regions of the oceans due to the generally more complex circulation patterns and biological activity (Riley and Skirrow, 1965). In this thesis, these nutrient variations were studied to determine their relationship to thermal fronts as sensed by satellite infrared imagery.

In recent years large areas of the oceans surrounding North America have been monitored by the National Oceanic and Atmospheric Administration's (NOAA) polar-orbiting satellites. These NOAA satellites send very high resolution radiometer (VHRR) data twice daily to three receiving stations (Brower et al, 1976). The satellite imagery of the eastern boundary of the North Pacific Ocean has revealed persistent thermal features in the sea surface which appear to be associated with ocean fronts and eddies. From the history of satellite pictures for the area of the ocean off the central California coast, it appears that cold water which has come to the surface as a result of upwelling has become intertwined within the California Current (Traganza, 1978). This intertwining of colder, upwelled water with the warmer water of the California Current which forms thermally banded eddies was the subject area of primary study for this thesis.

THEORY

CURRENT SYSTEM (CENTRAL CALIFORNIA)

Wooster and Reid (1963) describe the current system off the central California coast as made up of three main currents:

1) the southerly flowing California Current,

2) a northerly flowing California Countercurrent, and

3) seasonal upwelling currents.

The California Current is part of the North Pacific gyre. It transports cold, low salinity waters into the central California coastal area which are high in nutrients. Beneath the California Current, the northward flowing California Countercurrent transports warmer, high salinity waters into the study area which are also high in nutrients. During late fall or early winter, however, this countercurrent appears to reach the surface, displacing the California Current seaward, and it is then known as the Davidson Current. The Davidson Current appears to be related to the seasonal wind field, and as it develops in the late fall it is strengthened during periods of southwesterly winds (Reid et al, 1958).

If the prevailing winds are strong from the north or northwest as normally occurs in the central California coastal area during spring and summer, a period of upwelling is developed. The surface waters are transported away from the coast under the influence of wind stress and Coriolis force causing subsurface waters to rise and take the place of the water moving offshore. A result of this type of upwelling is the formation

of a partially closed circulation cell. During periods of upwelling, the central California coastal waters become low in temperature and high in nutrient content (Sverdrup et al, 1942). This upwelling can be very sporadic with the transition from a period of the Davidson Current to the upwelling period often being ill-defined. However, the opposite is also true, and the transition may be very abrupt if strong upwelling occurs early in the year (Smethie, 1973).

NUTRIENTS (NITRATE AND PHOSPHATE)

The nutrients studied in this thesis are reactive dissolved inorganic nitrate and reactive dissolved inorganic phosphate. The concentrations and distributions of both nitrate and phosphate have been studied a great deal for both are essential constituents of living organisms (Sverdrup et al, 1942). Redfield (1958) first pointed out that the chemical composition of the organic soft tissue formed by plants is relatively constant with roughly 16 atoms of nitrate for every atom of phosphate. In the deep waters of the ocean the ratios of these same elements which have been released from organic tissue also is very nearly 16 atoms of nitrate for each phosphate atom. The release to sea water of nitrate and phosphate in deep waters is a result of decomposition and respiration. This is represented by the statistical-stoichiometric model developed by Richards (1965), viz.,

$$\underbrace{(CH_2O)_{106}(NH_3)_{16}H_3PO_4}_{\text{organic matter}}+138\ O_2 == 106CO+122H_2O+\underbrace{16HNO_3+H_3PO_4}_{\text{nutrients}}$$

Distribution of the nutrients in the ocean and their relative concentrations are largely dependent on the biochemical cycle. The exchange of chemical elements between the sea and its biomass is a cyclic process whereby nutrients are withdrawn by photosynthesis and regenerated by bacteria and animal respiration (Redfield et al, 1963). In theory when the nutrient enriched deep water is brought up within the euphotic zone, plants will extract the phosphate and nitrate they need until they have depleted one or both of the elements. When animals eat this plant material, they "burn" about 90 per cent of it to obtain energy and use the remaining 10 per cent to build animal tissue. In this process animals require approximately the same nitrate to phosphate ratio as do plants. It is not known whether organisms have evolved to use nitrate and phosphate in a 16:1 ratio because that is the ratio present in the oceans' deep waters, or rather, is it the organisms which have established the ratio (Broecker, 1974)?

The ratio of nitrate to phosphate found in the surface waters of the ocean, however, is not very often the 16:1 ratio mentioned above. The nutrients within the euphotic zone are subject to many processes which alter their concentrations and relationship to each other. The ratio of the uptake of nitrogen to the uptake of phosphorus represents the net result of their removal into various particulate pools and their release from any of these pools. Examples of the particulate pools are phytoplankton, zooplankton, and non living particulate matter. The processes of uptake and release

from the different pools proceed at different rates. Also the rates of some of the processes in the photic zone and at depth differ between nitrate and phosphate (Banse, 1974). In the case of upwelling, the nutrient concentrations are subject to an additional change as a result of the mixing of nutrient enriched water from below the euphotic zone with the surface and near surface waters. The distribution of both nitrate and phosphate, therefore, depend not only on biological processes but also on physical processes.

CHEMICAL MESOSCALE

The concentrations and distribution of nutrients are among the principle factors in the central California waters that work in an interacting pattern to control the biological production (Traganza, 1978). The others include solar radiation, water temperatures, mixed layer depths, and the advective effects associated with upwelling. One of the purposes of this thesis and the follow on research being carried out at the Naval Postgraduate School is to investigate the interrelationships among the above mentioned factors on a mesoscale. To this end the incorporation of satellite data from the NOAA series satellites proves to be an invaluable asset in locating areas of active upwelling and recently upwelled water. The satellite's sea surface temperature sensor detects the lower sea surface temperatures associated with upwelled waters. References have been made occasionally in satellite literature to the correlation of upwelled nutrients with satellite-sensed

sea surface temperature, however, this is largely based on pre-satellite data (Traganza, 1978). A pertinent question then becomes, can satellites sense the dispersion of upwelled waters by the horizontal advection of surface currents, and if this can be related to the mesoscale features in the chemistry of the sea surface.

SATELLITE IMAGERY

During the pioneer days of orbiting satellites, the only information routinely obtained was day and night cloud coverage of the earth provided by thermal infrared (IR) scanners. Although it was thought that these IR measurements could be used to detect sea surface temperature if the sky was cloud free, the quality of the early sea surface IR images was very poor. As a result, satellite data was generally ignored by the oceanographic community (Legeckis, 1978). However, in October 1972 the National Aeronautics and Space Administration launched the first of its improved Television Infrared Observation Satellites (TIROS) series whose performance has enabled oceanographers to supplement their ground observations with satellite observations.

The TIROS satellites (later redesignated NOAA-2,3,4, and 5) were launched into sun-synchronous, 1450 kilometer orbits. Two of the three prime sensors on these satellites are dedicated to providing oceanic data. The Scanning Radiometer (SR) provides data in both the visible region (0.52μm to 0.73μm) and the thermal infrared region (10.5μm to 12.5μm) with a

spatial resolution of 4 kilometers and 7.5 kilometers, respectively. The other oceanic sensor is also a dual channel instrument, the Very High Resolution Radiometer (VHRR), with a 1 kilometer spatial resolution in both the visible and infrared regions. The VHRR imagery serves as the data source for the research on oceanic eddies and fronts (Sherman, 1977).

The next generation of polar orbiting operational environmental satellites, designated TIROS-N, was launched in October 1978. It is a multipurpose satellite. One of its sensors, which is of prime interest to oceanographers, is the Advanced Very High Resolution Radiometer (AVHRR). The AVHRR replaces both the SR and the VHRR on the earlier NOAA series satellites and was specifically designed for accurate, quantitative sea surface temperature mapping. Its improvements include a reduction in satellite noise, a more accurate compensation for atmospheric attenuation, and an improvement in the sensor's spatial resolution.

Sea surface temperatures, T_s, obtained from satellite thermal IR data are not measured directly. They are calculated from the measured radiance using the relation

$$T_s = T_{bb} + \Delta T$$

where ΔT is the atmospheric attenuation and T_{bb} is the measured equivalent blackbody temperature. The input energy measured by a satellite in the 10.5µm to 12.5µm spectral window is a function of the integrated radiation flux from the emitting surfaces of the viewed scene, the atmospheric gases (both

emitters and absorbers), and the spectral response function of the sensor filter. This is expressed mathematically as

$$N == \int_{\lambda_1}^{\lambda_2} I(\lambda)\, \Phi(\lambda)\, d\lambda$$

where N is the total response energy in the spectral window from λ_1 to λ_2 , $I(\lambda)$ is the input radiant energy, and $\Phi(\lambda)$ is the sensor filter response. The sensor then is designed to produce a linear relation between the output voltage and the input energy. This relation is the sensor's calibration function which has two divisions:

1) a thermal calibration which accounts for thermal effects on sensor responses, and
2) an electrical calibration which accounts for the shifts introduced into the electrical signal as it flows along the data path from the sensor to the central processing facility (Breaker et al, 1978).

The input radiant energy as viewed by the IR sensor is a function of three radiation sources. These three sources are radiation from an emitting surface (for example land, water, clouds, etc.), radiation from atmospheric gases, and radiation reflected from the ocean's surface. Within the IR (10.5μm to 12.5μm) spectral window, the ocean surface acts as a nearly perfect blackbody. Therefore, a value of unity is assumed for the emissivity of the ocean surface and the radiation reflected from the ocean surface can be neglected since there is no reflection from a blackbody. The input

radiant energy then becomes a sum of the first two terms above from which an equivalent blackbody temperature, T_{bb}, is calculated.

The value obtained for T_{bb} must be corrected for atmospheric attenuation to obtain a value for the sea surface temperature. Attenuation in the atmosphere occurs primarily due to the presence of water vapor, but carbon dioxide, ozone and aerosols also have an effect. The relative values of these absorbers is shown below:

absorber	correction range
H_2O vapor	0° to 9.0° C
CO_2	0.1° to 0.2° C
O_3	0.1° C
aerosols	0.1° to 0.95° C

The actual correction, ΔT, to be made is based on soundings made by the satellite's Vertical Temperature Profile Radiometer (VTPR) and is given mathematically by the relation

$$\Delta T = A \sec \theta + B \sec^2 \theta$$

where A and B are coefficients calculated from the VTPR soundings of the atmosphere and θ is the viewing angle measured from the satellite nadir point (Brower et al, 1976).

Sea surface temperatures are obtained from the NOAA satellites through the Global Operational Sea Surface Temperature Computation System (GOSSTCOMP). GOSSTCOMP is a computerized system under control of the National Environmental Satellite

Service and is made up of four main subsystems. The first of these subsystems is for orbital processing which is accomplished 13 to 14 times daily, once for each orbit of the satellite. The next subsystem is for daily processing and consists of a network of many programs. Daily processing is used to apply atmospheric corrections, to yield a quality control screen of the raw data, to allow global analysis, and to create special products. The third subsystem of GOSSTCOMP is for sea surface temperature verification. In this subsystem satellite derived sea surface temperatures are compared with available ship observations twice daily giving an indication of the overall system reliability. The final subsystem has a group of three supporting functions required by the sea surface temperature operation. These three functions are a monthly climatology update, an objective analysis tape archival, and a monthly sea surface temperature observation tape archival (Brower et al, 1976).

METHODS

SATELLITE IMAGERY

The satellite imagery was provided by the National Environmental Satellite Service receiving station in Redwood City, California, which monitored the NOAA-5 and TIROS-N satellites, and by the Naval Environmental Prediction Research Facility in Monterey, California, which monitored the Synchronous Meteorological Satellite (SMS-2). Direct telephone contact was set up with the Redwood City receiving station which afforded this study real time satellite information. The point of contact at Redwood City was the staff oceanographer, Mr. Laurence Breaker (or in his absence, Mr. Ron Gilliland), who was notified about seven days prior to each of the scheduled cruises. When alerted, the staff oceanographer would then closely monitor and enhance the NOAA-5/TIROS-N satellite images for oceanic features which would be of interest in our area of study. The final contact was made the early morning of the scheduled cruise, at which time the oceanographer would report the most up to date location and recent history of the oceanic feature from the satellite images.

Two important considerations in making the satellite images applicable to the study of oceanic features such as fronts and eddies are image enhancement and geometric corrections. Both of these functions were performed by the respective facilities mentioned above.

The satellite infrared detectors have a temperature response from approximately -90° to 60°C. The infrared data in this temperature range are normally displayed on gray tone photographic film to produce images of clouds, land, and water. The colder parts of the scene, such as clouds, are assigned lighter shades of gray. Because the range of sea surface temperatue extends from about 0° to 40° C, it is advantageous to assign the available shades of gray within this narrower temperature range, thus allowing the ocean SST fronts to be distinguished more clearly. This method of data processing is called image enhancement (Legeckis, 1978). In the enhancement of the NOAA-5 image (Plate 1) a temperature range was assigned to shades of gray with white equal to about 10°C and black 20°C. A similar enhancement of the SMS-2 image (Plate 2) ranged from 2° to 17°C. (Nagle, 1979), while the enhancement of the TIROS-N image (Plate 3) ranged from 7° to 22°C (Breaker, 1979). Comparison of visible and infrared images served as a means of locating cloudless areas. Identification of sea surface features was substantiated by their relative persistance.

Because of the earth's curvature and rotation and due to the method of data acquisition, satellite images are geometrically distorted. This distortion is especially pronounced with the polar-orbiting satellites because successive views of the same area on the earth are made from different angles, and the degree to which the data must be corrected

depends upon the accuracy required. The earth curvature and rotation errors can be removed approximately by application of a simple algorithm (VHRR data are not geometrically corrected on a routine basis). Although geometric corrections can put satellite data into a uniform perspective, accurate mapping of the data requires either precise satellite navigation or landmarks which can be identified on the image (Legeckis, 1978). For the location of the oceanic features in this study prominent coastal features such as Point Pinos and Point Sur, California, were used as landmarks. Approximate ranges and bearings were then calculated from the landmarks to the oceanic features of interest.

NUTRIENTS

A Technicon Autoanalyzer (Technicon Corporation, Tarrytown, New York) was used to measure reactive dissolved nutrients every two minutes from a depth of approximately three meters as seawater was continually pumped from a keel intake into a shipboard laboratory. Previous tests which compared the pumped samples with samples collected at pump depth showed no significant differences in the concentrations of the dissolved nutrients (Paulson, 1972). Nitrate here includes nitrite since nitrate is reduced to nitrite before measurement. However, according to Paulson's (1972) data there is little or no nitrite at this depth. Samples were collected and analyzed at an average rate of once every 0.6 kilometer,

while the ship was making an average speed of about 18 kilometers per hour.

Nitrate and phosphate were analyzed according to the Technicon Autoanalyzer Industrial Methods 175-72WM and 177-72WM (Technicon, 1973). Cadmium columns were prepared for nitrate analysis using the procedure in the Technicon Autoanalyzer II Industrial Method 100-70W-B (Technicon, 1978). On cruises II, III, and IV samples were collected every two minutes in cups from seawater which was pumped into the dry lab. For cruise V the seawater was pumped directly through the wash receptable of the Autoanalyzer and was sampled at the same rate.

For this cruise the sampling cups were filled with a saline solution and placed in the rotary sampling tray as washes. Cam number 127-B175 was used to time the appropriate sample to wash ratio of 2:1. A 30.5°/₀₀ saline solution was used as the standard diluent and as wash solution to avoid salt interference in the phosphate analysis. When distilled water was used as wash, two extra peaks appeared on each phosphate curve. When the saline solution was used as a wash, these extra peaks disappeared.

Several cadmium columns were prepared for nitrate analysis and conditioned prior to each cruise. The column was changed approximately every twelve hours, and the instrument was restandardized. Constant sampling of the seawater reduced flow through the column. This was probably due to the build up

of particulate matter. This reduction in flow affected the bubble pattern in the ammonium chloride coil and also reduced the nitrate standards. A computer program which adjusted for this slope change was used to calculate the results. After an initial standardization curve was recorded (10, 20 and 30 μg-at/L for nitrate and 1, 2, and 3 μg-at/L for phosphate), one standard was run every two hours. The units of the nutrient concentrations were then converted to μM/kg by use of the equality, 1 μg-at/L equals 1.205 μM/kg. Additional standards were run if any of the reagants were replaced with fresh reagants. After every ten samples, a wash was run to check the baseline.

Routine maintenance avoided many of the problems encountered while using an Autoanalyzer (see Operation Manual for the Technicon Autoanalyzer II System, Technical Publication No. TA 1-0170-20, 1972). The proportioning pump tubing was changed after two 24 hour cruises. After each run the cadmium column was disconnected and 0.2N NaOH was pumped through the instrument for 5 minutes followed by a 30 minute distilled water wash. The instrument was housed in two specially built cases which facilitated easy and safe transport for the instrument. One case contained the recorder, another held all other components. After loading and unloading, all the instruments' connections were carefully inspected, and when possible, the Autoanalyzer was loaded a day prior to each cruise and tested to ensure proper operation.

STATISTICS

Correlation values were calculated using the three parameters, nitrate, phosphate, and sea surface temperature (measured at 2.4 meters depth). Separate correlation values were determined for cruises III, IV, and V using the correlation function

$$r == \Sigma((x_i-\bar{x})(y_i-\bar{y}))/(\Sigma(x_i-\bar{x})^2(y_i-\bar{y})^2)^{\frac{1}{2}}$$

Four nitrate versus phosphate regression diagrams (Figures 5, 6, 10, and 14) were constructed. For each of these regression diagrams a line of best fit was calculated using the method of least squares to obtain the phosphate axis intercept and the slope which represents the ratio of change, $\Delta N/\Delta P$, of the two nutrients.

TEMPERATURE

The sea water temperature was recorded continuously by a strip chart recorder located in the dry lab on board the ACANIA. The thermistor was located in the ship's intake just above the keel at a depth approximately equal to the depth at which the nutrient sea water samples were taken. The equipment was compared with bucket thermometer readings of the sea surface and also with the surface temperatures obtained from expendable bathythermograph (XBT) traces. The sea surface (0.1m) thermometers were consistently 0.2° to

0.5°C higher than the thermistor recording. The XBT sea surface temperatures were consistently within ± 0.5 C of the thermistor recording.

RESULTS

CRUISE II

For this cruise the ACANIA departed Monterey on the morning of 9 October 1978 and followed the cruise track shown in Figure 1. Because of the total cloud cover, sea surface temperature information from satellite pictures was not anticipated. Therefore, the main purpose of cruise II was to serve as a shakedown cruise to check out the autoanalyzer and to learn how best to adapt it to satisfy the requirements for collecting the nitrate and phosphate data for this study.

Cruise II proved to be a very valuable tool in establishing the techniques to be employed both in data collecting and processing on later cruises. The data collected on cruise II are included here for completeness (Figure 2). The nitrate channel had to be secured after just more than four hours due to a failure of the cadmium column, so that for the remainder of the 24-hour cruise only phosphate and temperature data were collected.

CRUISE III

The ACANIA departed Monterey just prior to noon on 7 December 1978 for cruise III and followed the track shown in Figure 3. The winds had been very strong from the north-west for the previous two to three days with gale warnings and small craft advisories issued during this time. As a

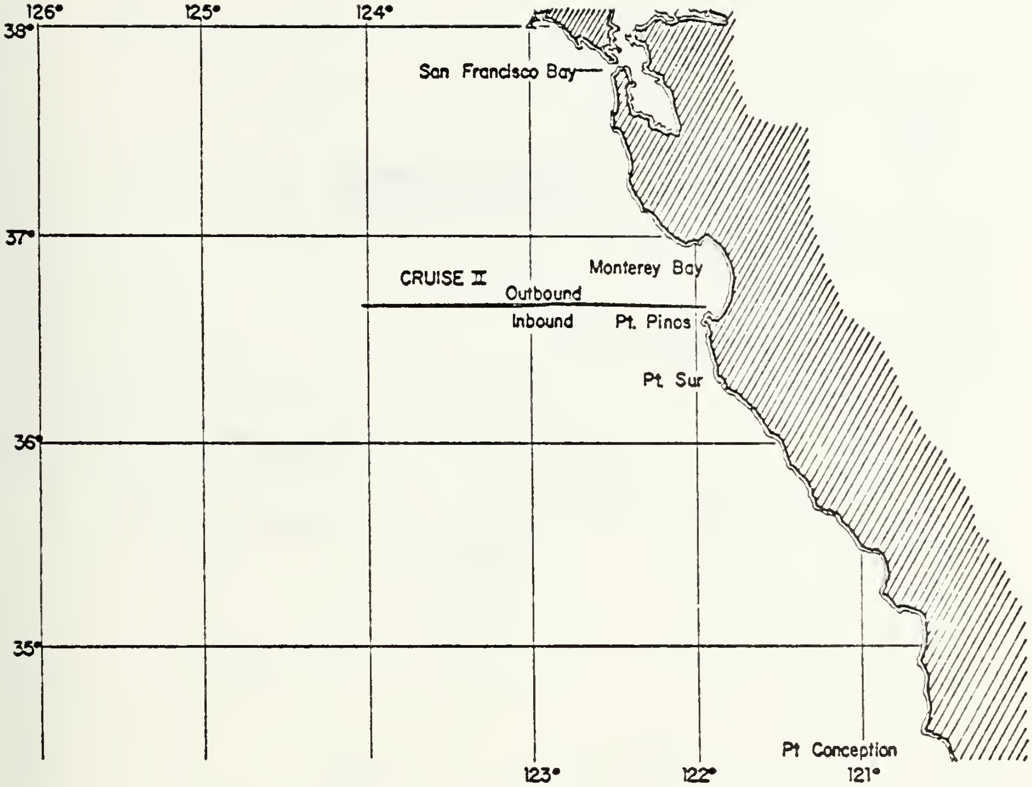

Figure 1. Cruise II ship's track.

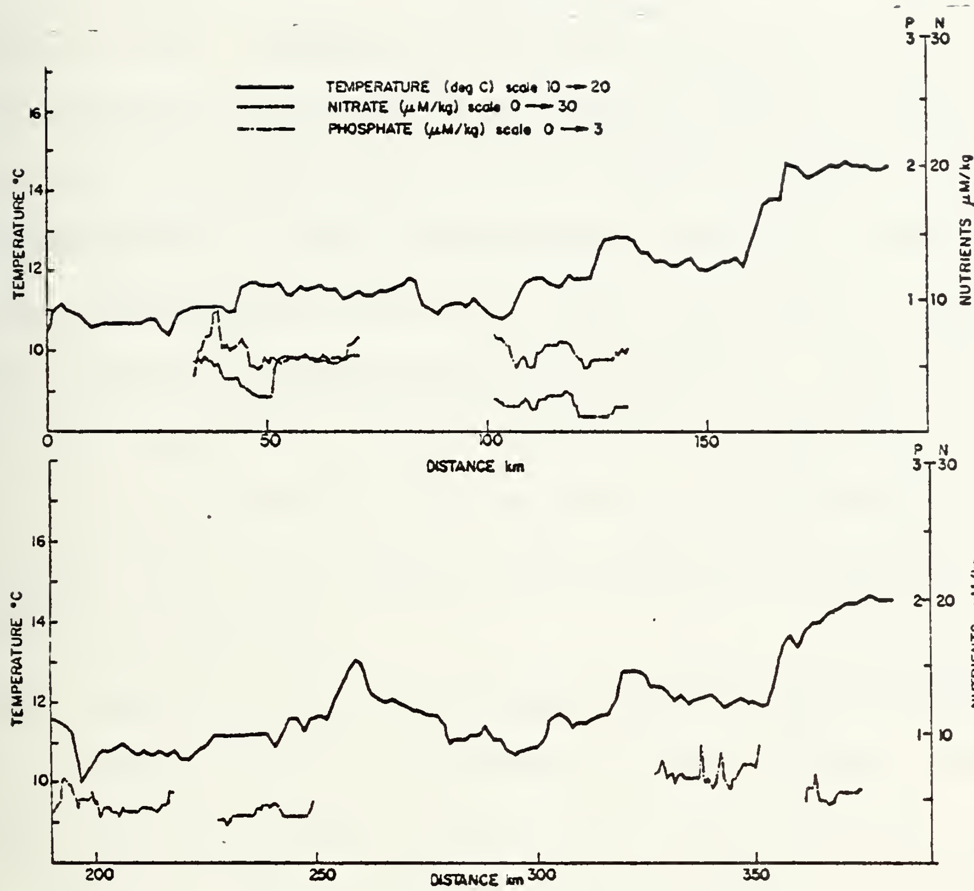

Figure 2. Nitrate, phosphate, and sea surface temperature versus distance along the track of Cruise II.

result, there was a plume of upwelled water which was detected by the NOAA-5 satellite (Plate 1) and is outlined by the dashed line in Figure 3. This satellite information was made available to Dr. Traganza in a phone conversation with Mr. Ron Gilliland at the satellite receiving station in Redwood City only a few hours prior to the ACANIA's getting underway. The optimum ship's track was selected from this information.

The data obtained along the track are shown in Figure 4 and are listed in tabular form in Appendix A. The starting point for cruise III and all the following cruises was Point Pinos. All the distances are measured in kilometers along the cruise track from the starting reference station at 36°38.3'N, 121°57.5'W.

The temperature trace in Figure 4 indicates a thermal front at about 60 to 70 kilometers on the outbound leg and at very nearly the same distance from the end of the inbound leg. There also appears to be a strong negative correlation between the temperature line and both the nitrate and the phosphate lines. This is verified by the correlation values obtained for cruise III which were found to be 0.963 for nitrate to phosphate, -0.960 for nitrate to temperature, and -0.915 for phosphate to temperature.

The nitrate and phosphate data are also shown in Figures 5 (outbound leg) and 6 (inbound leg). The linear regression analysis for this cruise yielded the slopes and phosphate axis intercepts of 16.17 and 0.51 μM/kg (outbound leg) and 14.95

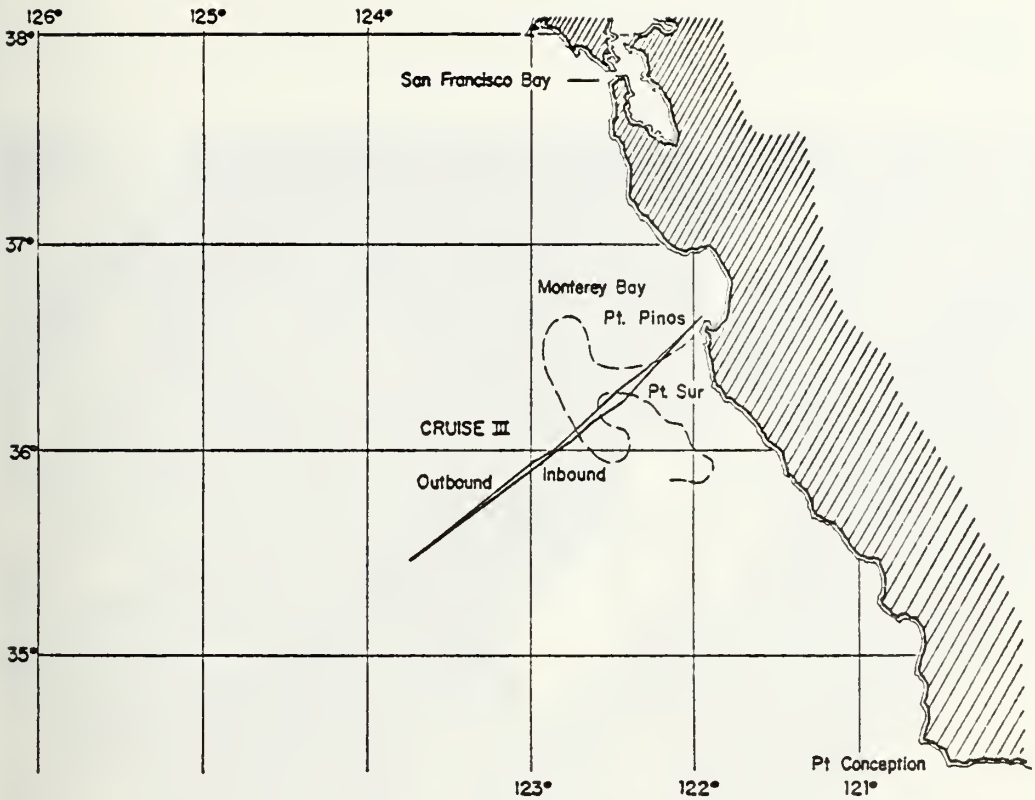

Figure 3. Cruise III ship's track (solid line) and outline of upwelling "plume" (dashed line).

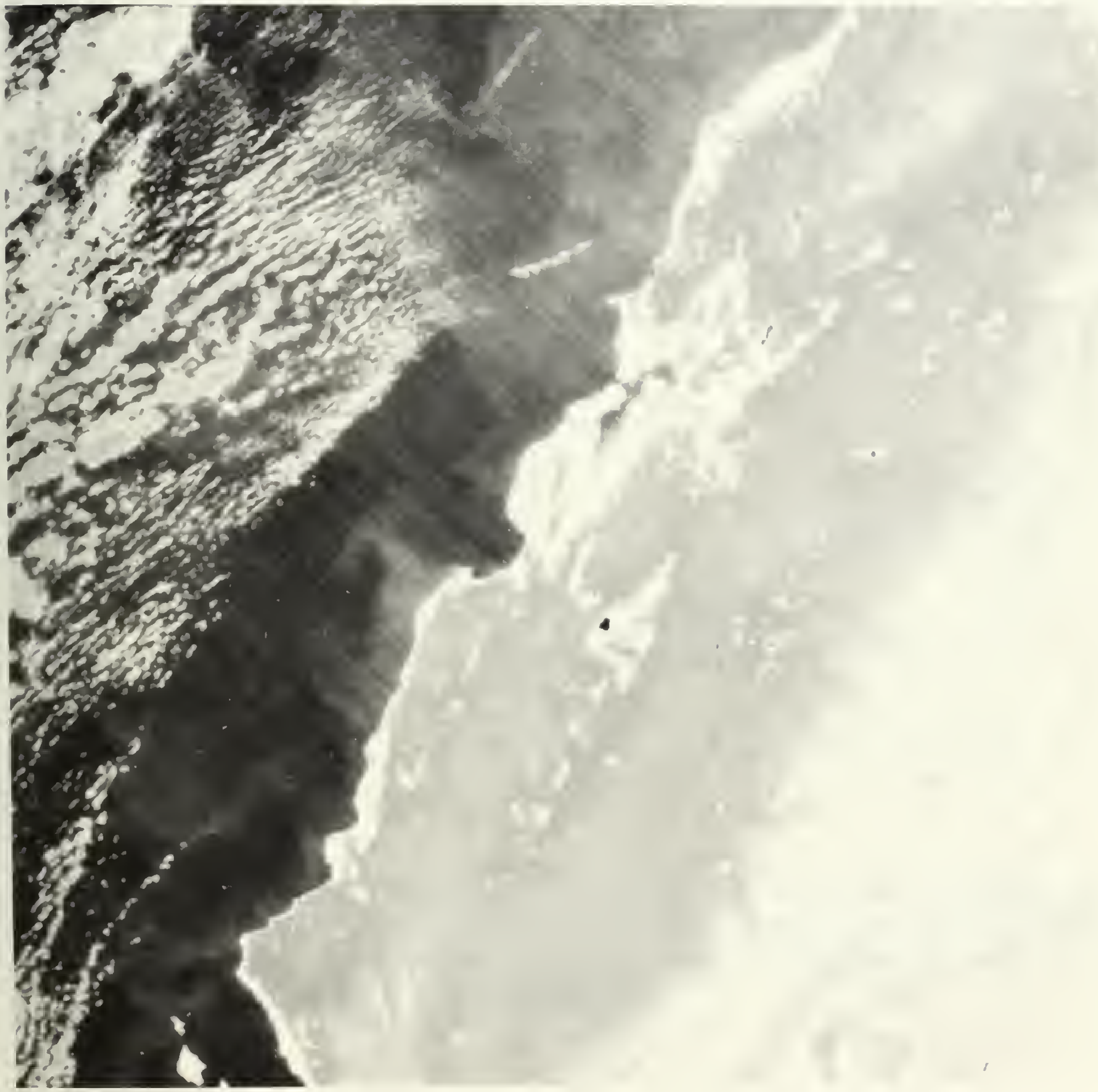

Plate 1. NOAA-5 satellite image of the California coast, 7 December 1978, Cruise III. Note Monterey Bay at the center with adjacent T-shaped cold water "plume" (white is ca 10°C and black is ca 20°C).

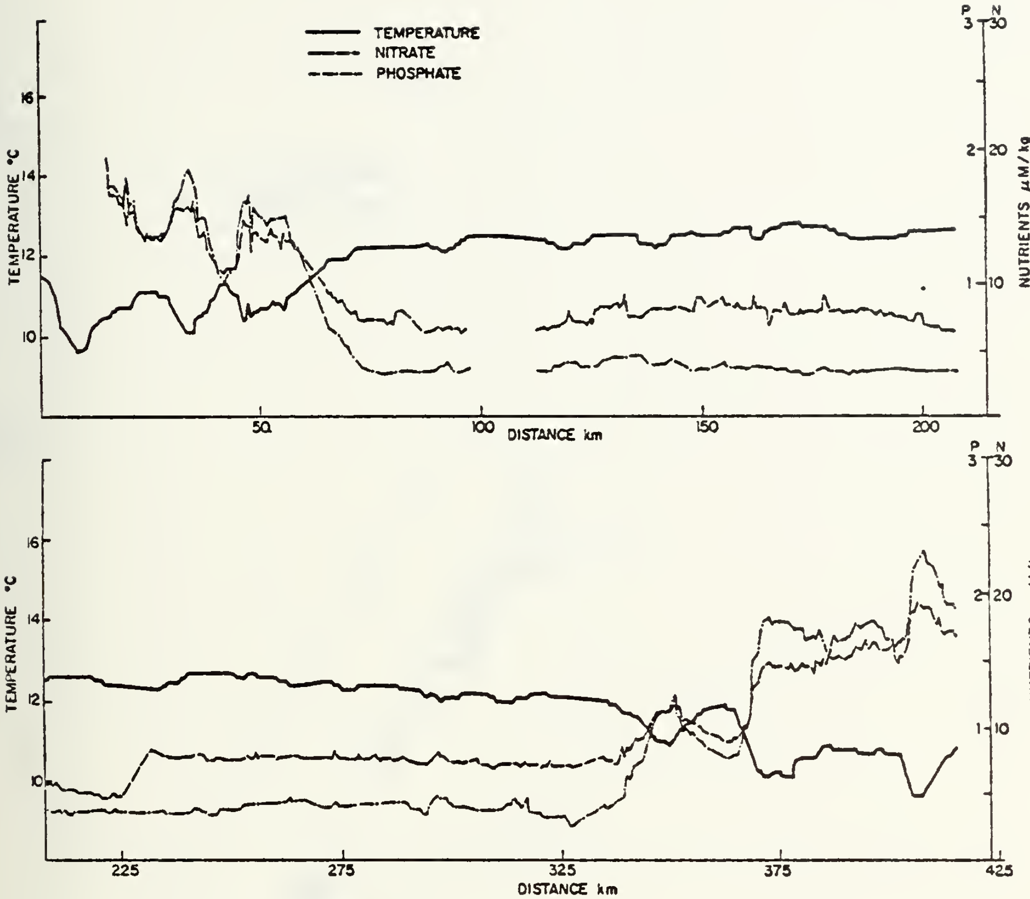

Figure 4. Nitrate, phosphate, and sea surface temperature versus distance along the track of Cruise III. Note the excellent inverse correlation of temperature and nutrients.

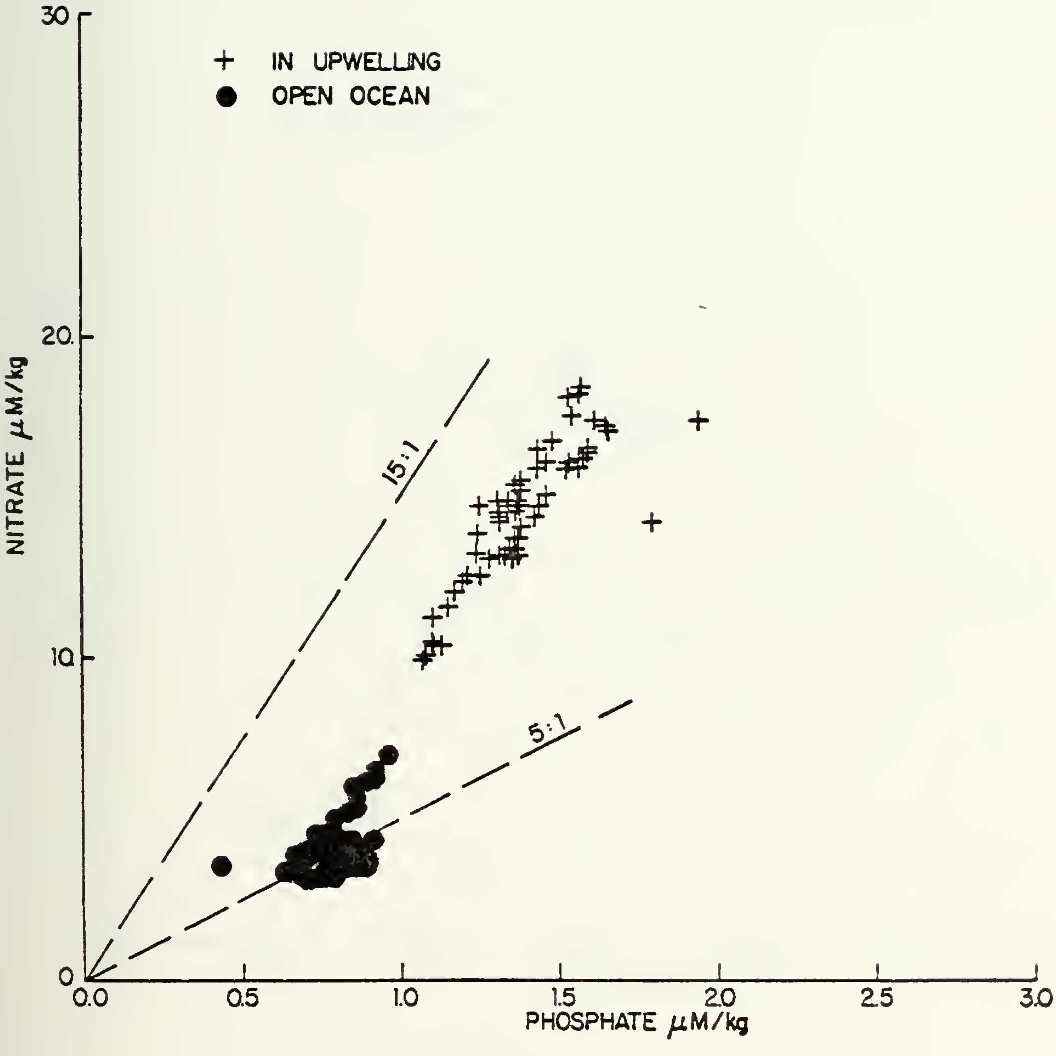

Figure 5. Regression analysis of nitrate versus phosphate for the outbound leg of Cruise III. (5:1 and 15:1 are arbitrary slope lines)

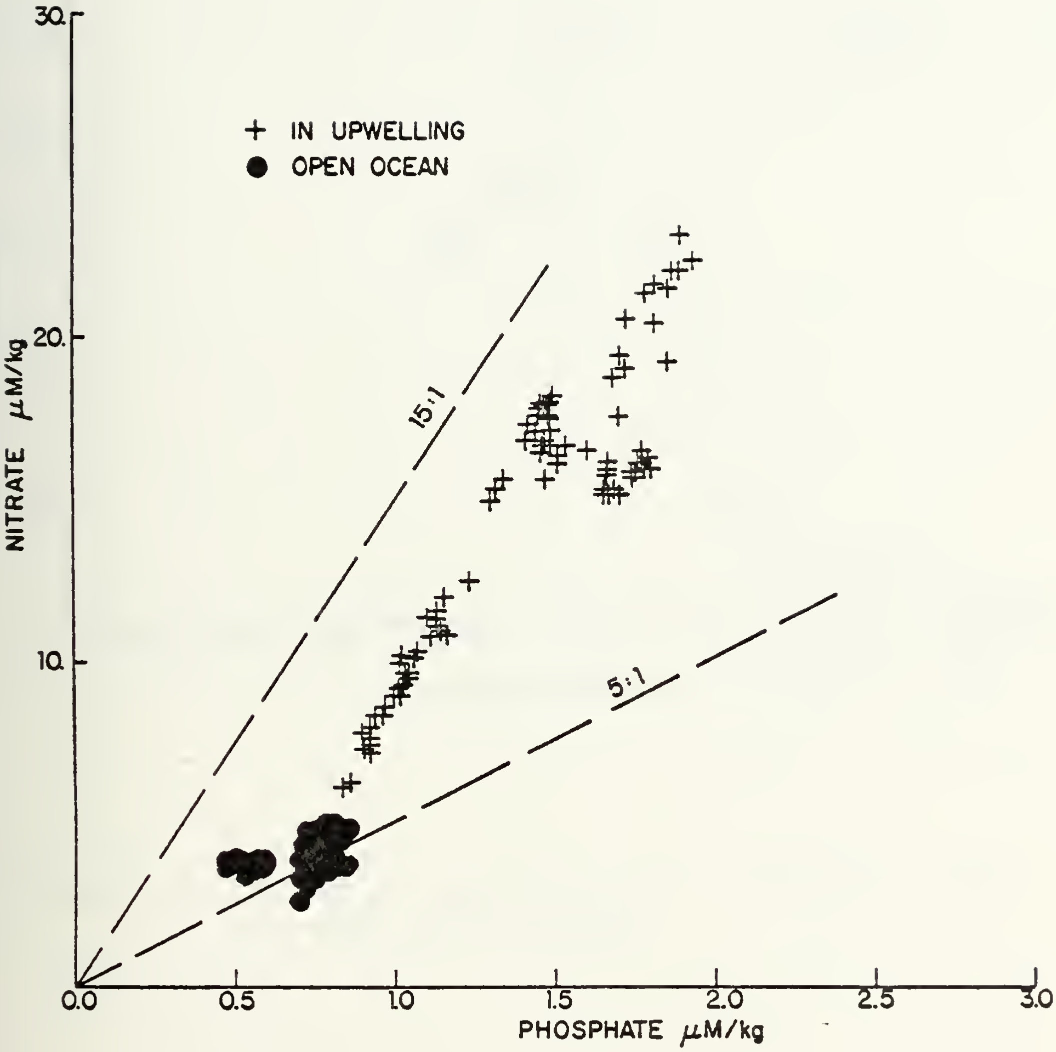

Figure 6. Regression analysis of nitrate versus phosphate for the inbound leg of Cruise III. (5:1 and 15:1 are arbitrary slope lines)

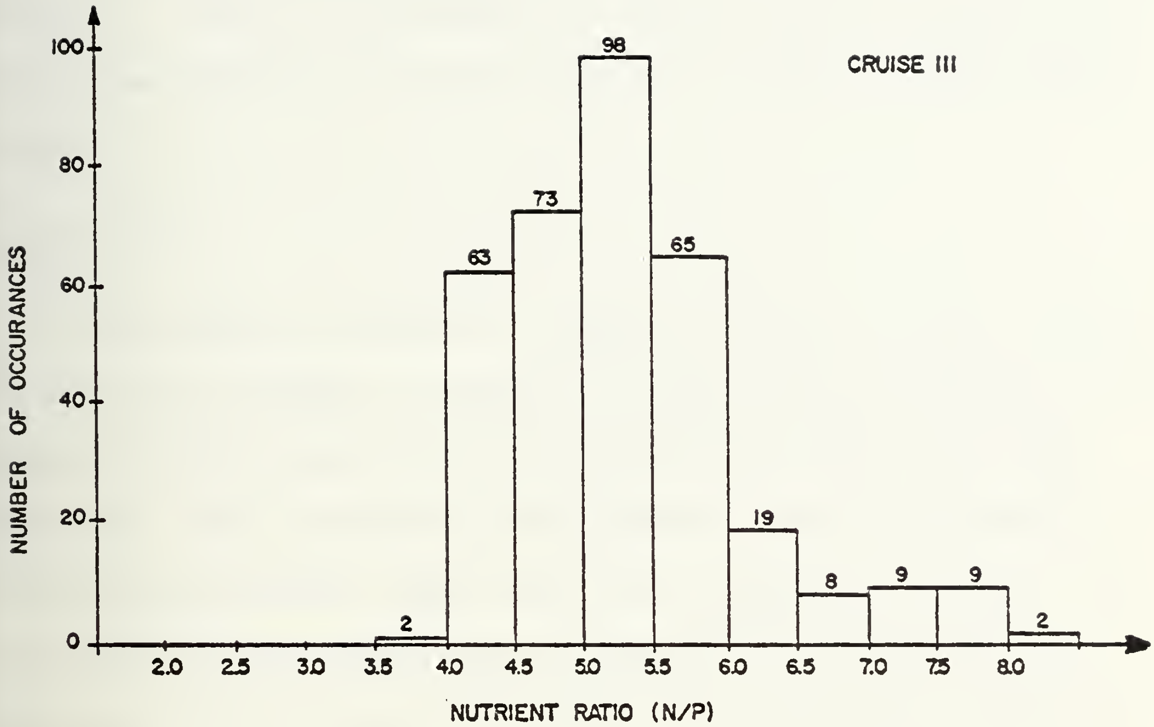

Figure 7. Cruise III nutrient ratio frequency chart for open ocean waters.

and 0.44 μM/kg (inbound leg). The nitrate to phosphate ratios calculated from the data collected on cruise III in the waters outside the plume of upwelled water are shown in Figure 7. From this graph the modal value of the nutrient ratio was found to be very close to 5:1 for the open ocean water.

CRUISE IV

The track for cruise IV, shown in Figure 8, was selected so that any thermal or nutrient concentration changes in the surface waters caused by the Davidson Sea Mount could be detected. The cruise followed several days of inclement weather with rains, high winds, and a general overcast, so that sea surface temperature information from satellite pictures was not available prior to the ACANIA's departure from the pier. However, satellite pictures for the day of the cruise (Plate 2) were available from the SMS-2 satellite upon the ship's return. These pictures showed that the surface waters were nearly isothermal for the entire area of the cruise. The satellite picture is verified by the nearly isothermal temperature line which is shown in Figure 8.

In addition to the nearly isothermal temperature trace in Figure 9, both the nitrate and phosphate lines are much less variable and more limited in range than they were for the Cruise III data shown in Figure 4. This is also illustrated in Figure 10 which is the nitrate-phosphate regression diagram for cruise IV and shows a much tighter grouping of

the data points. Cruise IV, therefore, serves as a good reference cruise for a non-upwelling period. The mean value of the dissolved nitrate and phosphate for cruise IV were determined to be 3.56 μM/kg and 0.53 μM/kg respectively. These mean values agree very closely with the values obtained in the California Cooperative Oceanic Fisheries Investigations for the same time of the year (Thomas and Siebert, 1974).

The nitrate to phosphate ratios calculated from the cruise IV data are shown in Figure 11. Although the modal value is very close to the value found on cruise III, Figure 11 shows a much wider spread in the nutrient ratios. The modal value 5.5:1 is also much less pronounced for cruise IV than it was for cruise III.

CRUISE V

Cruise V, which took place on 26 March 1979, followed several days of very good weather. An analysis of the satellite picture information by Mr. Laurence Breaker (NESS, Redwood City) indicated the presence of coastal upwelling to the south of Monterey Bay. The largest area of cold water was located about 25 miles off-shore from Morro Bay. The ACANIA departed the pier and headed south following the track indicated in Figure 12. Unfortunately, the cruise had to be shortened due to the presence of heavy seas which were generated by a large storm moving into the area from the south. Plate 3 is the TIROS-N satellite picture which was taken on 25 March 1979, the day prior to the cruise,

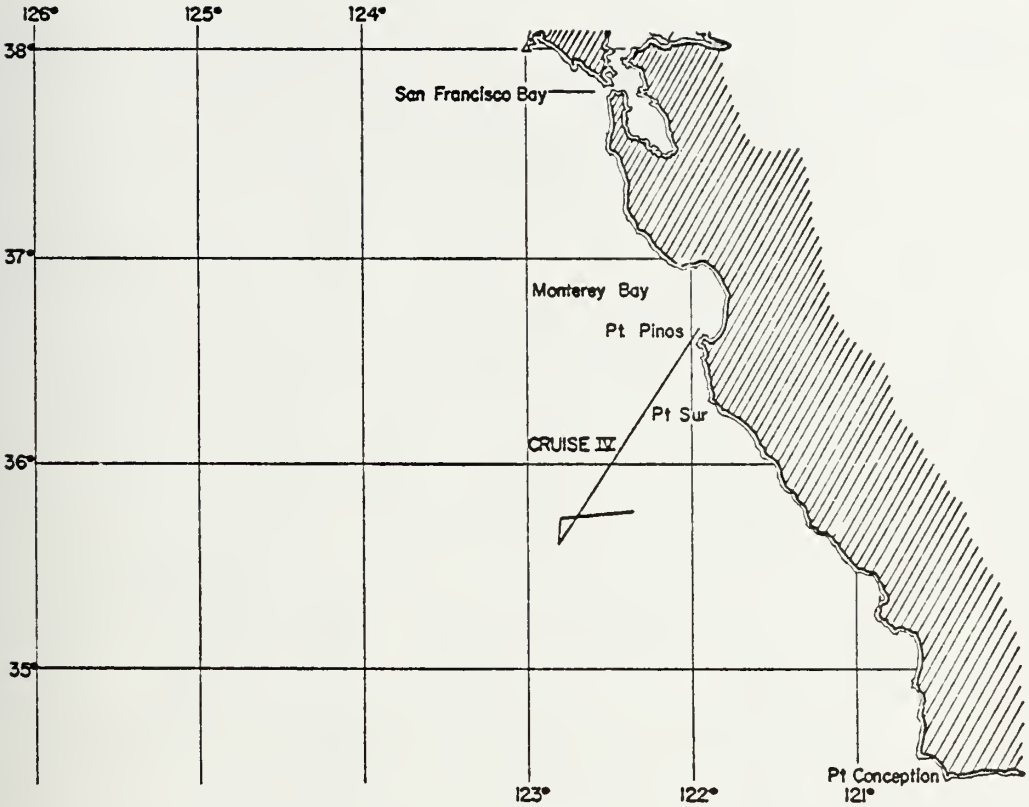

Figure 8. Cruise IV ship's track.

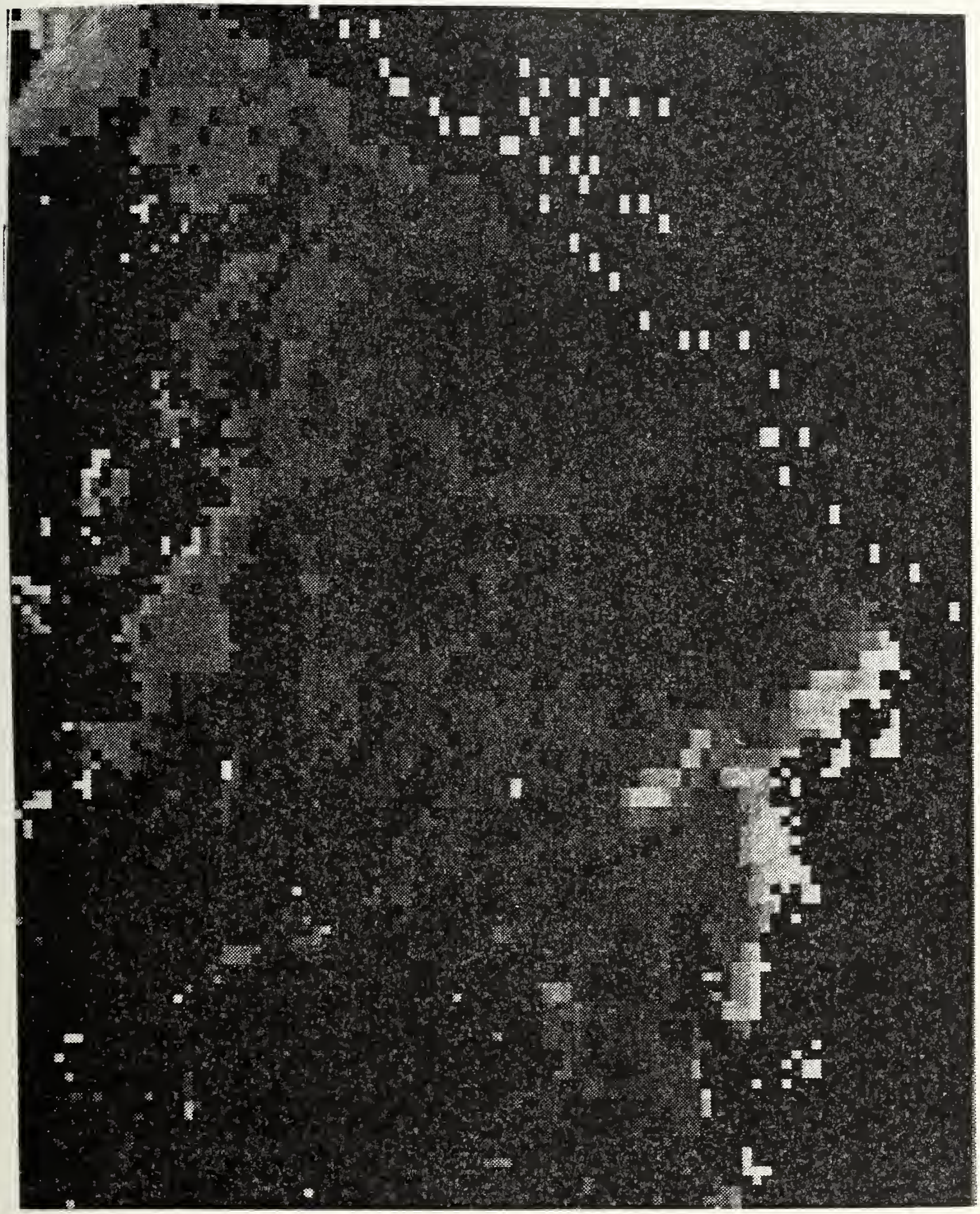

Plate 2. SMS-2 satellite image of the California coast, 20 January 1979, Cruise IV. Note Monterey Bay at the center with large adjacent isothermal region (white is ca 2°C black is ca 17°C).

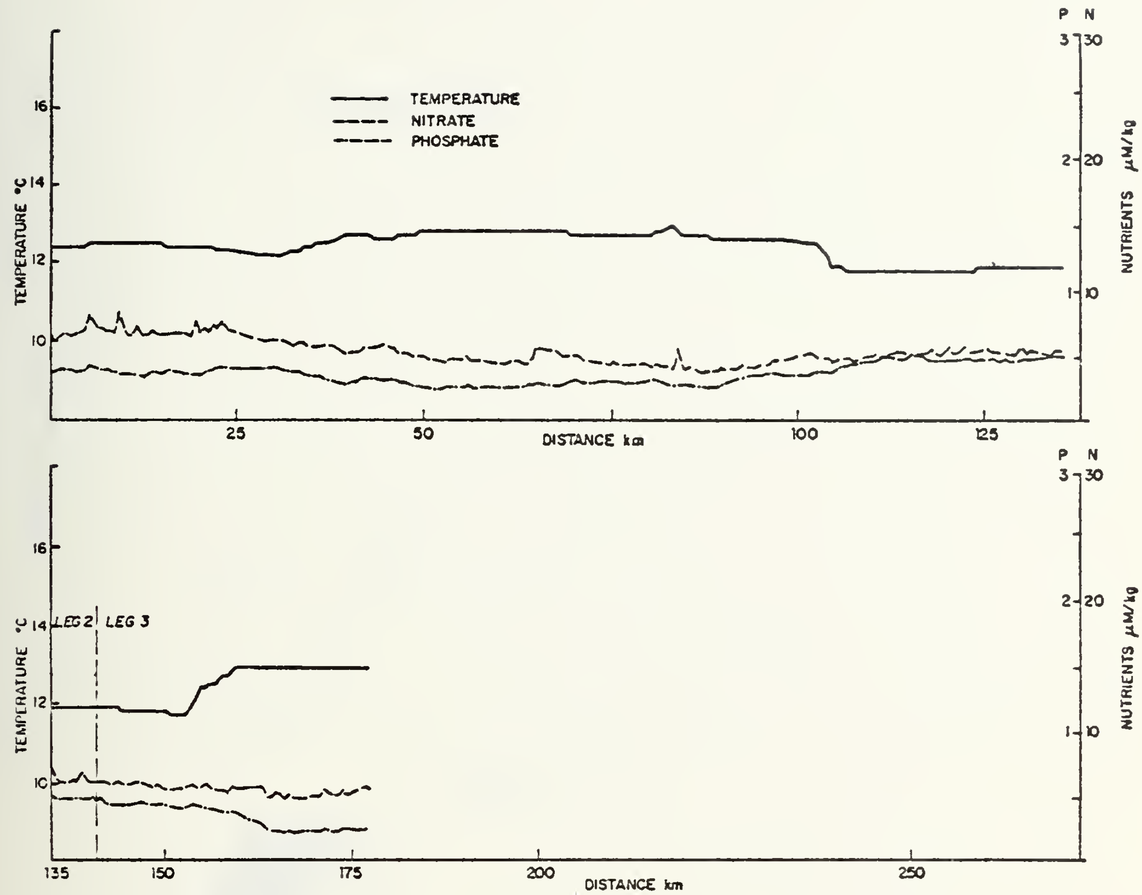

Figure 9. Nitrate, phosphate, and sea surface temperature versus distance along the track of Cruise IV.

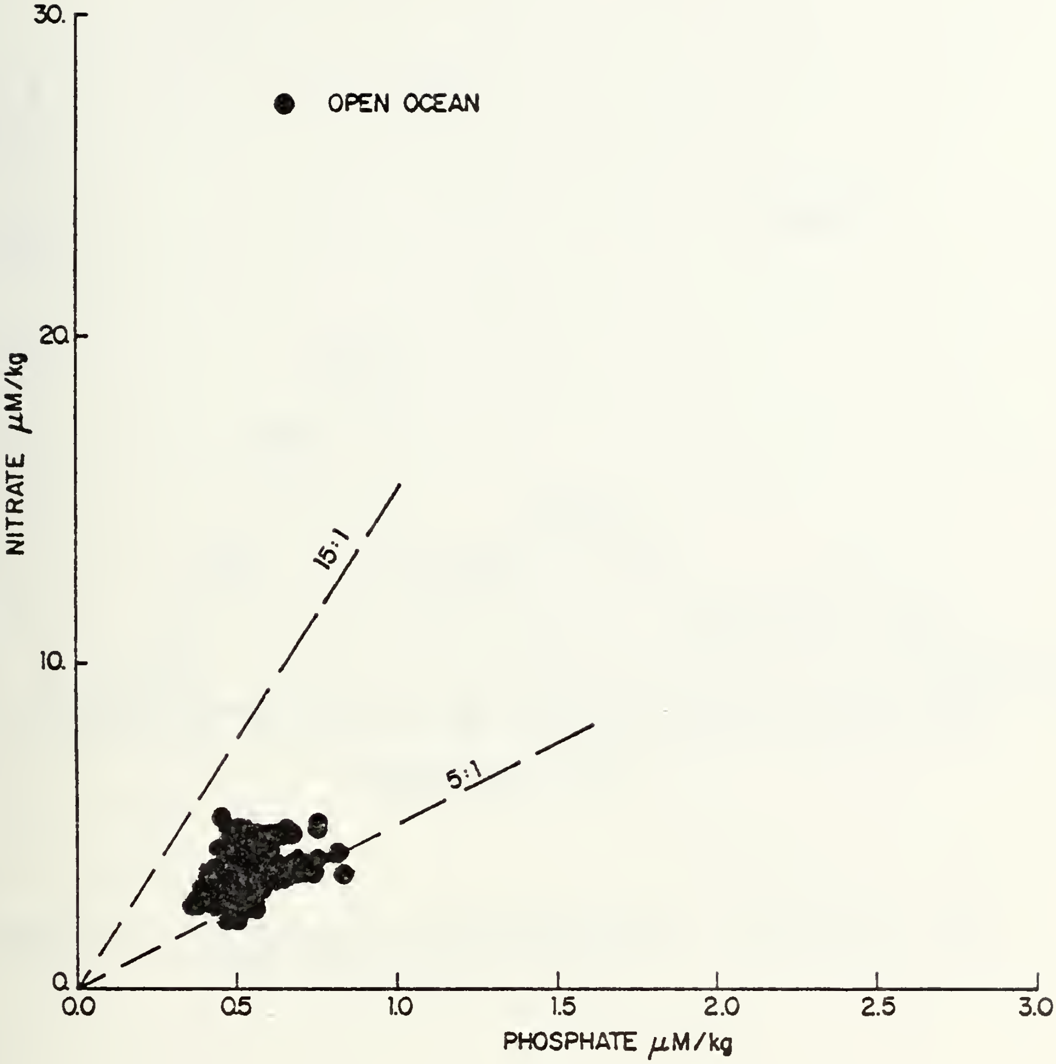

Figure 10. Regression analysis of nitrate versus phosphate for Cruise IV. (5:1 and 15:1 are arbitrary slope lines)

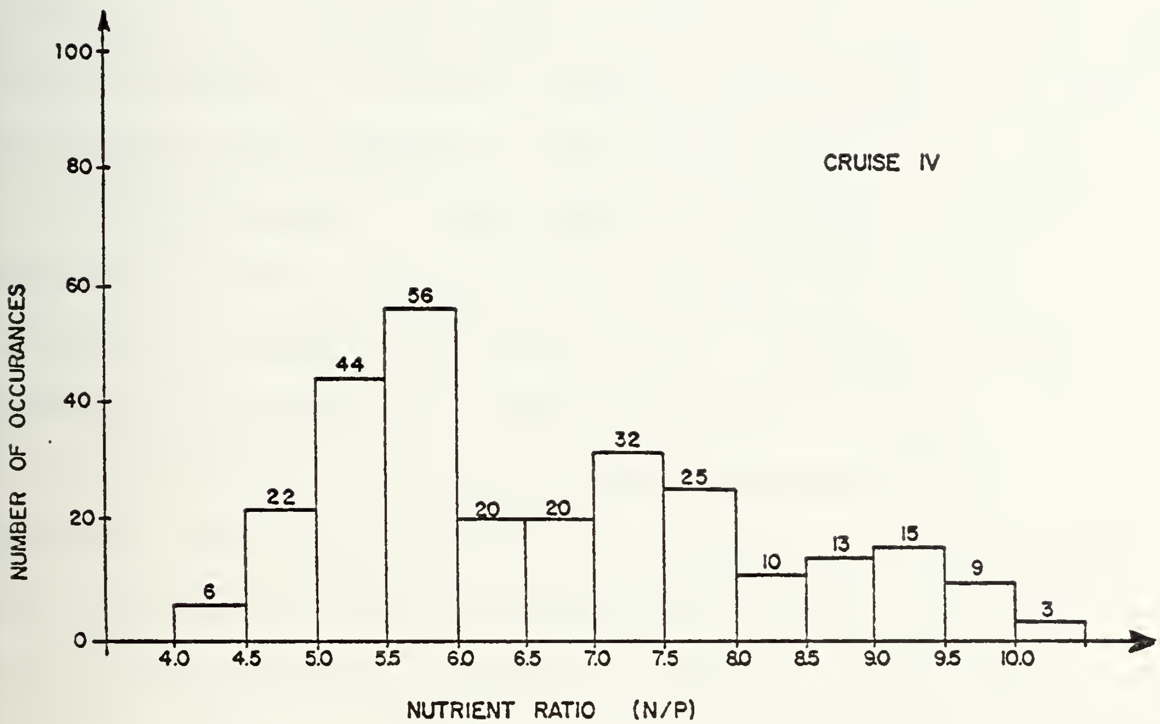

Figure 11. Cruise IV nutrient ratio frequenty chart for open ocean waters.

and it is on this picture that the coastal upwelling was detected to the south.

Although cruise V had to be cut short and the ship was operating in very heavy seas, the nutrient data obtained were very informative. For this cruise, as explained previously, the samples were pumped directly through the wash receptacle of the Autoanalyzer. This proved to be a much more efficient method of operation, especially in terms of the man-hours required to operate the Autoanalyzer. The data obtained are displayed in Figure 13. There is a strong negative correlation between the nutrients and the temperature and a strong positive correlation between the nitrate and the phosphate. The correlation values calculated for cruise V are 0.926 for nitrate to phosphate, -0.837 for nitrate to temperature, and -0.793 for phosphate to temperature. The close correlation found between nitrate and phosphate is also given in figure 14 where the data points show a very linear trend. The line of best fit for Figure 14 gave a slope of 12.19 and a phosphate axis intercept of 0.55 μM/kg.

In Figure 15 the nitrate to phosphate ratios calculated for cruise V are shown. These nutrient ratios show a wide spread of values and give no modal value. The ratio values between 4:1 and 6.5:1 are dominant, however, This range contains the modal values for the two previous cruises.

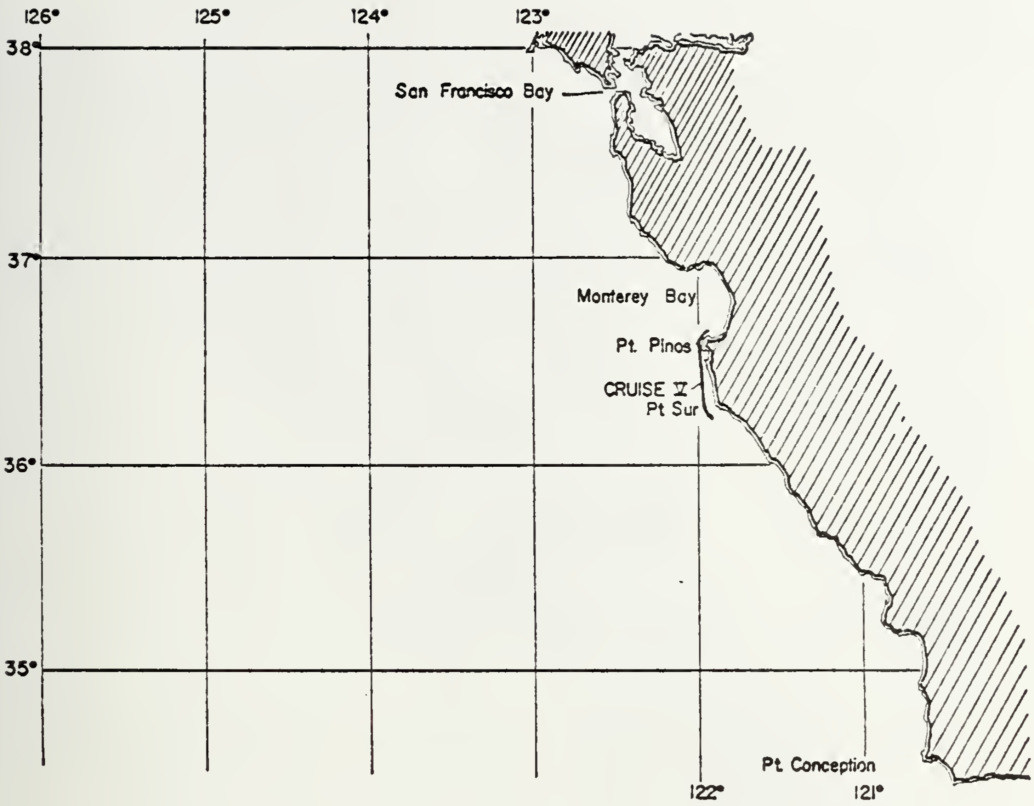

Figure 12. Cruise V ship's track.

Plate 3. TIROS-N satellite image of the California coast, 25 March 1979, Cruise V. Note Monterey Bay at the center with adjacent coastal cold water upwelling (white is ca 7°C and black is ca 22°C).

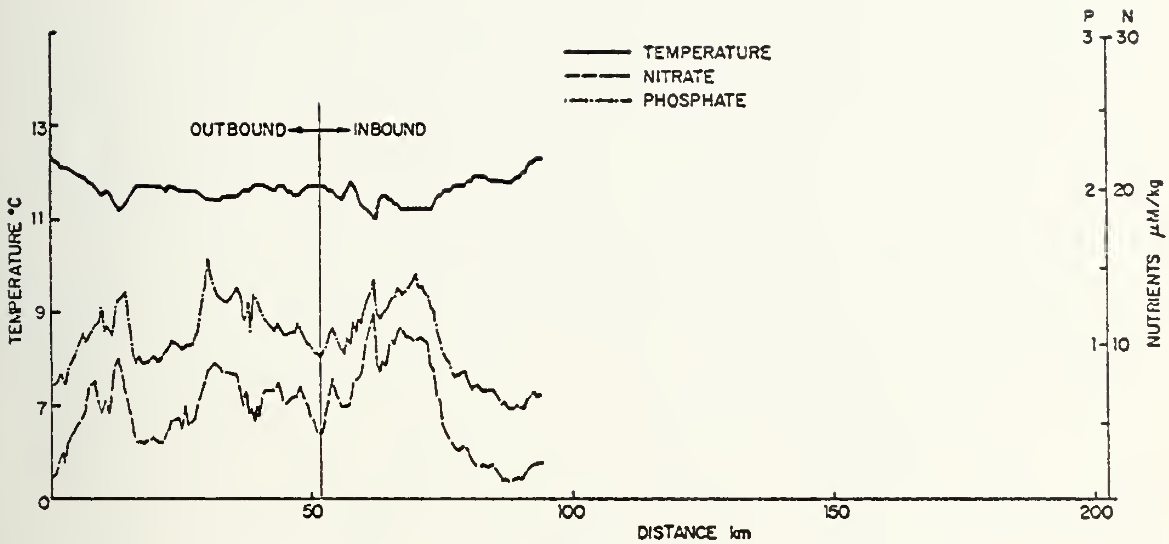

Figure 13. Nitrate, phosphate, and sea surface temperature versus distance along the track of Cruise V.

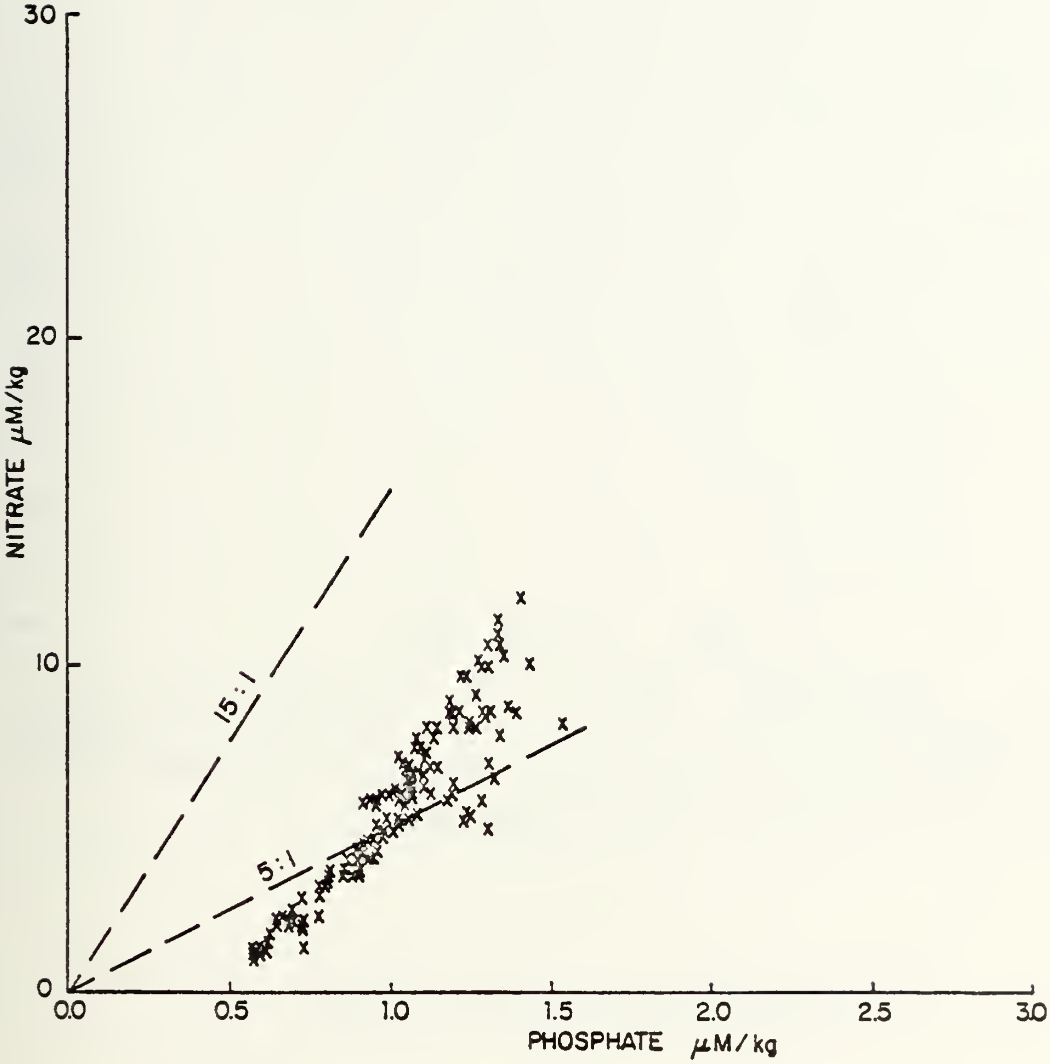

Figure 14. Regression analysis of nitrate versus phosphate for Cruise V. (5:1 and 15:1 are arbitrary line of slope lines)

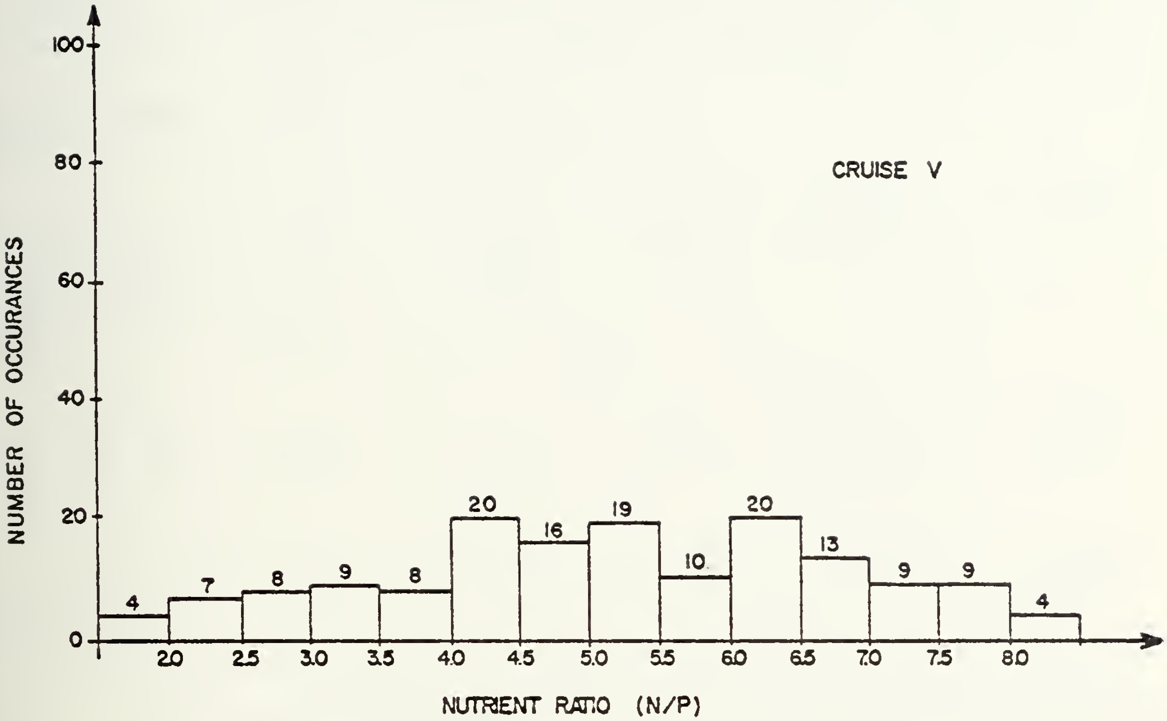

Figure 15. Cruise V nutrient ratio frequency chart for open ocean waters.

TABLE I

Summary of regression analyses

Cruise (date)	$\bar{N}$ (µM/kg)	$\bar{P}$ (µM/kg)	Correlation Coefficients N:T	P:T	N:P
II (9 Oct 78)	4.09	0.51			
III (7 Dec 78)	6.69	0.89	-0.96	-0.92	0.96
in upwelled water	14.51	1.40			
IV (20 Jan 79)	3.56	0.53	-0.93	-0.32	0.43
V (26 Mar 79)	5.45	1.00	-0.84	-0.79	0.93

$\bar{N}$ is nitrate, $\bar{P}$ is phosphate, and T is temperature in degrees Celsius.

TABLE II

Indices of biochemical nutrient utilization

Cruise (date)	Slope ($\Delta N/\Delta P$)	P-axis intercept ($\mu M/kg$)
III (7 Dec 78)		
Outbound leg	16.2	0.51
Inbound leg	14.9	0.44
IV (20 Jan 79)	*	*
V (26 Mar 79)	12.2	0.55

*Slope and P-axis intercept values are not applicable for Cruise IV due to limited range of the data.

DISCUSSION

The most promising aspect of the satellite observations in this study is that they showed that a large area of the ocean can be rapidly and thoroughly searched for oceanic features. It was shown possible to obtain accurate positions for these features from satellite images thus greatly facilitating experimental design. This is not only of interest in basic ocean research, however. It may also be of interest in many ASW applications. The satellite imagery utilized for cruise III (Plate 1) is an excellent example of how good satellite information can be an aid to an oceanographic study. Just prior to this cruise a strong thermal pattern, apparently from upwelling cold water was observed off the central California coast by satellite imagery. Initially the colder water evidencing upwelling curved northward, but on about the third day of its life, when the ACANIA put to sea, it had extended southward as well. There is a distinct possibility that this was the early stage in the evolution of a nutrient cell. When the upwelling season comes and good weather makes satellite observations more frequent, it may be possible to examine the formation and evolution of a fully developed cell.

In the satellite images for both cruise III and cruise V an area of upwelling was recognized by the plumes or bands of cold water which are characteristic of an upwelling. In earlier pre-satellite studies made in two of the world's major upwelling areas, one off the coast of Peru and the

other off the coast of northwest Africa, the surface temperature structure was related to other parameters. It was found that the nutrients and chlorophyll were distributed in the same pattern as the temperature in these areas (Walsh, 1972). In the central California coastal upwelling ecosystem mesoscale nutrient cells apparently do form when there is a concentrated pulse of upwelled water. Such cells impart an initial thermochemical mesoscale structure to the open ocean ecosystem. The inverse correlation between each of the nutrients (nitrate and phosphate) and the temperature was extremely good for cruise III in the three day old upwelling pulse (-0.96 and -0.92). Persistance of this strong inverse correlation depends on subsequent interactions of both biological and physical processes with varying scales and periods. Cruise V is a possible example where the inverse correlation is reduced by these interactions. The satellite image (Plate 3) which was from the day prior to the cruise indicated relatively weak upwelling near the coast. The nutrient values obtained on cruise V, however, were not as characteristic of upwelled waters. Both the nitrate and phosphate concentrations were above the open ocean values obtained on cruises III and IV, but well below the mean values within the upwelled area on cruise III. Also the minimum sea surface temperature observed on cruise V was 11.0°C, which is over a degree higher than the temperatures observed in the upwelled water. The inverse correlation values between the temperature and nutrients

(-0.837 and -0.793), although still very good, are not nearly as strong as was obtained on cruise III. The decrease in the strength of the inverse correlation could be the result of mixing and downwelling associated with the passage of a storm. It could also be due partially to a smaller energy input associated with the weaker upwelling prior to cruise V.

By way of contrast are the satellite observations of cruise IV (Plate 2), which show a largely isothermal sea surface with no indications of upwelling. This satellite picture was verified by the in situ data. The mean nutrient concentrations were the lowest observed for any of the cruises (see Table I) and the temperature trace (Figure 9) was very nearly isothermal. The inverse correlation values between the nutrients and the temperature remained very good for temperature to nitrate (-0.929) but was very poor for temperature to phosphate (-0.319).

The nutrient concentrations as measured by the methods used in this study include both oxidative nutrients and preformed nutrients. The distinction between these two names for the nutrients is defined by Redfield, Ketchum, and Richards (1963). They define oxidative nutrients as nutrients that have been oxidized or regenerated from organic matter and preformed nutrients as nutrients that are present in the water at the time it sinks from the surface. According to the model of Richards (1965), the oxidized nutrients are "returned to solution through the metabolic activities of the

marine community" at a rate of 16 nitrogen atoms for each phosphorus atom. In deep oceanic water, the ratio of dissolved nitrate to dissolved phosphate remains very close to this 16:1 ratio. In the surface waters, the ratio of these nutrients was found in this study never to get as high as 16:1. For the last three cruises, the values of the ratios ranged from 1.9:1 to 12.4:1. The lower values correspond to the ratios found in the open ocean areas and the higher values correspond primarily to the upwelled water. This range of values agrees very closely with the annual range for the nutrient ratio of 3:1 to 13:1 obtained in a study by Butler et al (1979). Nutrients present in the upwelling water may be characterized as biochemically old on the basis of the relatively high nutrient ratios. This also suggests that these nutrients are of oxidative origin. Nutrients in the open ocean waters were found in this study to have a nitrate to phosphate ratio whose modal value approached 5:1. This suggests that these nutrients are mostly preformed nutrients.

The phosphate and nitrate ions are primarily supplied to the surface waters from below the thermocline by upwelling and mixing processes (Dugdale, 1967). Once in the surface waters the nutrients are then removed from solution by phytoplankton. According to Banse (1974), the ratio of change of nitrate to phosphate, $\Delta N/\Delta P$, is the net result of several processes of removal and release of the nutrients from

various particulate pools, the rates of which can vary with both time and depth. The distribution of the nutrients depends not only on physical processes but also on the presence of organisms and the mechanisms and kinematics of the regeneration processes. Therefore, neither the nutrient concentrations nor the ratios obtained on the three cruises of this study can be expected to remain constant for very long. This is shown by the in situ nutrient data collected which do indicate a large amount of variability. This variability is demonstrated very well in the results of cruise IV. Within the large nearly isothermal region studied on this cruise there was observed a range in the values of nitrate concentration from 5.24 to 2.14 μM/kg, phosphate concentration from 0.83 to 0.36 μM/kg, and the nutrient ratio from 11.6:1 to 4.2:1.

The ratio of change of nitrate and phosphate, $\Delta N/\Delta P$, in seawater has been related to the elementary composition of phytoplankton (Redfield, 1934). Since the rate of removal of nitrate is 16 times the rate of removal of phosphate, initial concentrations of nitrate which may be an order of magnitude higher than phosphate concentrations in recently upwelled water can decline to an undetectable level while phosphate declines to a low but still detectable level. This ratio of change of the nutrients, $\Delta N/\Delta P$, is characteristic of their uptake by phytoplankton down to levels where further uptake becomes inhibited (Ketchum, 1939). The ratio is found from the linear regression analysis of nitrate on

phosphate and is the slope of the linear best fit. Theoretically the value of the slope should be 16:1. The values obtained in this study (16.2:1 and 14.9:1) on cruise III do agree very closely with the theoretical value. The slope on the nitrate-phosphate plot for cruise V (12.2:1) is also very close to the theoretical value (see Table II). The excellent agreement of the cruise III values with theory is especially interesting because it indicates the ratio of change of the nutrients across an ocean front associated with a recent intense upwelling. The slope, $\Delta N/\Delta P$, for cruise IV was not calculated because the high density of the data points with very little scatter would not give a meaningful value.

In summary:

(1) The utilization of satellite imagery was shown to be a very effective method to localize an ocean front for study. Direct telephone contact between the satellite receiving station and the research vessel ACANIA provided the up-to-date positions of the oceanic features of interest, thus improving our ability to study them.

(2) A high inverse correlation between nutrient concentrations and sea surface temperature was found

(N vs T = -0.960 and P vs T = -0.915) in the case of a recent, strong upwelling. This inverse correlation, however, was significantly lower in the open ocean waters as was the case on cruise IV (P vs T = -0.319).

3) The nitrate to phosphate ratio, N/P, ranged from 1.9:1 to 12.4:1 in this study. The higher values were found within the upwelled water suggesting the nutrients are primarily of oxidative origin and the water is biochemically old. The open ocean ratios were lower and had an overall modal value of 5:1, which suggests the nutrients present were mainly the preformed nutrients which are present in the water at the time it sinks from the surface.

4) The ratio of change of the nutrients, $\Delta N/\Delta P$, was observed to be 16.2:1 and 14.9:1 for Cruise III and 12.2:1 for Cruise V. These observed values compare favorably with the theoretical 16:1 ratio.

APPENDIX A

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISEII)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NITR.RATIO NO3/PO4	TEMP DEG C
1613	36 38.3	121 57.5	0.0					12.3
			1.8					13.0
			3.7					13.0
			5.5					13.0
			7.3					12.9
			9.1					12.8
			11.2					12.6
			13.0					12.7
			14.9					12.7
1700	36 40.1	122 4.8	16.6					12.7
			18.5					12.7
			20.5					12.3
			22.3					12.8
			24.1					12.5
			26.0					12.4
			27.8					12.9
			29.6					13.0
1800	36 40.3	122 15.8	33.5		4.09	0.52		13.1
			34.0		5.00	0.55		13.1
			34.6		5.95	0.53		13.1
			35.1		5.91	0.50		13.1
			35.7		6.59	0.55		13.1
			36.2		7.05	0.53		13.1
			36.8		7.05	0.52		13.1
			37.3		7.27	0.52		13.1
			37.9		8.86	0.48		13.1
			39.0		9.09	0.50		13.1
			39.5		6.14	0.44		13.1
			40.1		6.36	0.37		13.1
			40.6		6.14	0.38		13.1
			41.2		6.36	0.39		13.0
			41.7		5.91	0.38		13.0
			42.2		6.14	0.39		13.0
			43.3		6.36	0.39		13.0
			43.9		6.59	0.33		13.0
			44.4		6.81	0.33		13.0
			45.0		6.36	0.31		13.6
			45.5		6.14	0.30		13.6
			46.1		4.77	0.28		13.6
			47.2		4.77	0.26		13.7
			47.7		4.55	0.25		13.7
			48.3		4.55	0.25		13.7
			48.8		4.77	0.25		13.7
1900	36 40.4	122 26.6	49.4		5.45	0.25		13.7
			49.9		5.22	0.25		13.7
			50.5		5.00	0.26		13.6
			51.0		5.45	0.26		13.6
			51.6		5.45	0.45		13.6
			52.1		5.22	0.52		13.6
			53.2		5.00	0.55		13.6

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			53.8		5.22	0.55		13.6
			54.3		5.22	0.56		13.7
			54.9		5.45	0.55		13.7
			55.4		5.45	0.55		13.7
			56.0		5.45	0.55		13.4
			56.5		5.45	0.53		13.4
			57.1		5.45	0.53		13.4
			57.6		5.45	0.55		13.4
			58.2		5.45	0.55		13.4
			58.7		5.68	0.55		13.4
			59.3		5.45	0.53		13.6
			59.8		5.45	0.53		13.5
			60.4		5.45	0.52		13.6
			61.5		5.22	0.52		13.5
			62.0		5.45	0.52		13.5
			62.6		5.68	0.52		13.5
			63.1		5.45	0.52		13.6
			63.6		5.45	0.50		13.6
			64.2		5.22	0.50		13.6
			64.7		5.45	0.50		13.6
			65.3		5.45	0.50		13.6
2000	36 40.5	122 37.4	65.8		5.45	0.50		13.5
			66.4		5.45	0.52		13.5
			66.9		5.45	0.52		13.5
			67.5		5.45	0.53		13.5
			68.0		5.45	0.55		13.5
			68.6		6.36	0.56		13.5
			69.1		6.36	0.56		13.5
			69.7		6.59	0.56		13.3
			70.2		6.82	0.55		13.5
			70.8		7.01	0.56		13.5
			72.6					13.4
			74.3					13.5
			75.9					13.5
			77.7					13.6
			79.6					13.7
			81.4					13.8
2100	36 40.7	122 48.4	83.2					13.7
			84.7					13.1
			86.5					13.0
			88.2					12.9
			90.0					13.1
			91.6					13.2
			93.5					13.2
			95.1					13.1
			96.9					13.3
2200	36 40.7	122 59.1	98.6					13.1
			100.4					12.9
			101.5		2.36	0.71		12.8
			102.1		2.36	0.68		12.8

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISEII)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			102.6		2.11	0.68		12.8
			103.2		2.11	0.68		13.0
			103.7		1.84	0.66		13.0
			104.3		1.84	0.63		13.0
			104.8		1.84	0.53		13.4
			105.4		1.84	0.55		13.4
			105.9		1.84	0.52		13.4
			106.4		1.84	0.47		13.7
			107.0		1.84	0.50		13.7
			107.5		2.11	0.53		13.7
			108.1		2.11	0.55		13.8
			108.6		2.36	0.53		13.8
			109.2		2.11	0.47		13.9
			109.7		1.58	0.47		13.8
			110.3		1.58	0.47		13.8
			110.8		1.58	0.53		13.8
			111.4		2.36	0.58		13.8
			111.9		2.36	0.58		13.7
			112.5		2.36	0.61		13.6
			113.0		2.36	0.63		13.6
			113.6		2.63	0.53		13.6
			114.1		2.63	0.63		13.6
			114.7		2.63	0.63		13.6
2300	36 39.8	123 9.7	115.2		2.63	0.63		13.6
			115.8		2.63	0.63		13.8
			116.3		2.63	0.56		13.9
			116.9		2.63	0.66		13.9
			117.4		2.89	0.66		13.9
			118.0		2.89	0.66		13.8
			119.1		2.63	0.63		13.8
			119.6		1.84	0.58		13.8
			120.2		1.84	0.55		13.8
			120.7		1.05	0.53		14.0
			121.3		1.05	0.53		14.3
			121.8		1.05	0.47		14.5
			122.4		1.05	0.47		14.6
			122.9		1.05	0.47		14.8
			123.5		1.05	0.53		14.8
			124.0		1.05	0.53		14.8
			124.6		1.05	0.53		14.8
			125.1		1.05	0.53		14.8
			125.7		1.05	0.53		14.8
			126.2		1.05	0.53		14.8
			127.3		1.05	0.53		14.8
			127.8		1.32	0.53		14.7
			128.4		1.32	0.53		14.6
			128.9		1.84	0.58		14.5
			129.5		1.84	0.56		14.4
			130.0		1.84	0.58		14.4
			130.6		1.84	0.61		14.4

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISEII)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			131.1		1.84	0.59		14.4
2400	36 39.8	123 21.0	131.7		1.84	0.61		14.4
			133.5					14.4
			135.3					14.2
			137.2					14.2
			139.0					14.1
			140.8					14.2
			142.7					14.3
			144.5					14.0
			146.3					14.1
0100	36 40.2	123 32.0	148.1					14.2
			150.0					14.3
			151.8					14.1
			153.6					14.7
			155.5					15.2
			157.3					15.7
			159.1					15.8
			161.0					16.7
			162.8					16.6
0200	36 39.7	123 43.3	164.6					16.5
			166.4					16.3
			168.3					16.4
			170.1					16.5
			171.9					16.6
			173.8					16.7
			175.6					16.6
			177.4					16.6
			179.2					16.5
0300	36 39.5	123 54.3	181.1					16.5
			182.9					16.6
			183.8			0.47		13.6
			184.4			0.38		13.6
			185.5			0.44		13.6
			186.0			0.47		13.5
			186.6			0.63		13.5
			187.1			0.63		13.5
			187.7			0.59		13.4
			188.2			0.59		13.4
			188.8			0.53		13.4
			189.3			0.50		13.2
			189.9			0.41		12.8
			190.4			0.47		12.4
			190.9			0.47		12.0
			191.5			0.47		12.1
			192.0			0.47		12.2
			192.6			0.47		12.3
			193.1			0.53		12.3
			193.7			0.44		12.5
			194.2			0.44		12.6
			194.8			0.34		12.6

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISEII)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			195.9			0.41		12.6
			196.4			0.41		12.8
			197.0			0.41		12.8
0400	36 39.6	123 58.4	197.5			0.38		12.8
			198.1			0.38		12.8
			198.6			0.38		12.9
			199.2			0.34		12.8
			200.3			0.41		12.9
			200.8			0.38		12.9
			201.4			0.38		12.9
			201.9			0.38		13.0
			202.5			0.38		13.0
			203.0			0.38		12.9
			203.6			0.38		12.8
			204.1			0.41		12.8
			204.7			0.41		12.9
			205.2			0.41		12.7
			205.8			0.41		12.7
			206.3			0.41		12.7
			206.9			0.41		12.9
			207.4			0.38		12.8
			208.0			0.38		12.8
			208.5			0.41		12.7
			209.1			0.44		12.7
			209.6			0.44		12.7
			210.2			0.44		12.8
			210.7			0.54		12.8
			211.2			0.53		12.8
0500	36 39.4	123 48.2	212.7					12.7
			214.2					12.8
			215.6					12.6
			216.7					12.6
			218.4					12.9
			220.0					12.9
			221.7			0.32		13.1
			222.2			0.32		13.1
			222.8			0.32		13.1
			223.1			0.32		13.2
			223.5			0.29		13.2
			224.1			0.29		13.2
			224.6			0.32		13.2
			225.1			0.35		13.2
			225.7			0.35		13.2
			226.2			0.35		13.2
			226.8			0.35		13.2
			227.3			0.35		13.2
0600	36 39.6	123 37.4	227.9			0.35		13.2
			228.4			0.35		13.2
			229.0			0.35		13.2
			229.5			0.35		13.2

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISEIII)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			230.1			0.33		13.2
			230.6			0.41		13.2
			231.2			0.41		13.2
			231.7			0.44		13.2
			232.3			0.44		13.2
			232.8			0.44		13.2
			233.4			0.41		13.2
			234.5			0.44		13.2
			235.0			0.44		13.2
			235.6			0.41		13.2
			236.1			0.38		13.2
			236.7			0.35		13.2
			237.2			0.35		13.1
			237.8			0.35		13.0
			238.3			0.35		12.9
			238.9			0.35		13.0
			239.4			0.35		13.1
			240.0			0.35		13.2
			240.5			0.35		13.3
			241.1			0.35		13.5
			241.6			0.35		13.6
			242.2			0.38		13.6
			242.7			0.41		13.6
0700	36 39.7	123 26.2	243.3			0.47		13.5
			245.1					13.4
			246.9					13.6
			248.7					13.7
			250.6					13.6
			252.4					14.0
			254.2					14.4
			256.1					14.8
0800	36 39.7	123 15.1	257.9					15.1
			259.7					14.9
			261.5					14.2
			263.4					14.1
			265.2					14.0
			267.0					14.1
			268.9					14.0
			270.7					13.9
			272.3					13.8
0900	36 39.8	123 4.1	274.2					13.7
			276.0					13.7
			277.8					13.5
			279.7					13.0
			281.5					13.1
			283.3					13.1
			285.1					13.2
			287.0					13.2
1000	36 40.4	122 52.9	288.6					13.4
			290.4					13.1

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			292.3					13.1
			294.1					12.8
			295.9					12.7
			297.8					12.8
			299.6					12.9
			301.4					12.9
1100	36 40.3	122 42.1	303.2					13.1
			305.1					13.6
			306.7					13.7
			308.6					13.6
			310.4					13.4
			312.2					13.5
			313.9					13.7
			315.7					14.1
			317.5					14.3
1200	36 40.0	122 31.0	319.3					14.7
			320.1			0.67		14.4
			321.5			0.69		14.4
			322.6			0.78		14.4
			323.2			0.69		14.4
			323.7			0.64		14.4
			324.3			0.67		14.4
			324.8			0.67		14.3
			325.4			0.61		14.3
			326.5			0.67		14.2
			327.0			0.67		14.1
			327.6			0.64		14.1
			328.1			0.64		14.1
			328.7			0.64		14.2
			329.2			0.64		14.2
			329.8			0.64		14.1
			330.3			0.64		14.0
			330.9			0.64		14.0
			331.4			0.87		14.1
			332.0			0.61		14.1
			332.5			0.61		14.1
			332.9			0.64		14.2
			333.2			0.61		14.2
1300	36 39.8	122 20.2	333.8			0.56		14.2
			334.9			0.61		14.2
			336.0			0.83		14.2
			336.5			0.64		14.2
			337.1			0.61		14.1
			337.6			0.56		14.1
			338.2			0.56		14.1
			338.7			0.64		14.0
			339.3			0.64		13.9
			339.8			0.69		13.9
			340.4			0.72		14.0
			340.9			0.75		14.0

R/V ACANIA 9 OCT 78 CHEMICAL MESOSCALE(CRUISE11)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			341.5			0.75		14.0
			342.0			0.75		14.1
			342.6			0.75		14.1
			343.1			0.75		14.1
			343.7			0.72		14.0
			344.2			0.69		14.0
			344.8			0.67		14.0
			345.3			0.64		14.0
			345.9			0.64		14.0
			346.4			0.67		14.0
			347.0			0.67		13.9
			347.5			0.67		13.9
			348.1			0.67		13.9
1400	36 39.7	122 16.4	349.5					14.0
			350.3					14.7
			352.1					15.4
			353.2					15.7
			354.1					15.4
			355.0			0.47		15.3
			355.6			0.57		15.9
			356.7			0.57		16.0
			357.2			0.57		16.0
			357.8			0.47		16.0
			358.3			0.47		16.0
			358.8			0.47		16.0
			359.4			0.47		16.1
			359.9			0.44		
			360.5			0.44		16.3
			361.6			0.47		16.4
			362.1			0.53		16.4
			362.7			0.53		16.5
			363.2			0.53		17.5
			363.8			0.53		16.5
1500	36 39.8	121 58.1	364.3			0.53		16.5
			364.9			0.53		16.6
			365.4			0.53		16.7
			366.0			0.53		16.6
			366.5			0.53		16.6
			367.1			0.56		16.6
			367.6			0.56		16.6

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
1928	36 32.8	121 34.3	15.2		17.44	1.94	9.0	10.5
			15.8		17.24	1.65	10.4	10.5
			16.3		17.24	1.65	10.4	10.6
			16.9		17.24	1.65	10.4	10.6
			17.4		16.91	1.65	10.2	10.7
			18.0		16.58	1.59	10.4	10.7
			18.5		16.42	1.59	10.3	10.7
			19.0		16.25	1.57	10.4	10.7
			19.6		14.27	1.79	8.0	10.7
			20.1		15.92	1.52	10.5	10.7
			20.7		15.92	1.52	10.5	10.7
			21.2		16.09	1.53	10.5	10.9
			21.8		14.77	1.43	10.3	11.0
			22.3		14.11	1.38	10.2	11.1
			22.8		13.78	1.36	10.1	11.1
			23.4		13.45	1.34	10.0	11.1
			23.9		13.28	1.31	10.1	11.1
			24.5	143.7	13.45	1.37	9.8	11.1
			25.0		13.28	1.35	9.8	11.1
			25.6	342.9	13.28	1.34	9.9	11.1
			26.7		13.28	1.34	9.9	11.1
			27.2		13.12	1.35	9.7	11.0
			27.7	222.7	13.28	1.37	9.7	11.0
			28.3		13.45	1.35	10.0	11.0
			28.8		13.78	1.37	10.1	11.0
2100	36 27.0	122 11.0	29.4	343.6	14.44	1.42	10.2	10.9
			29.9		15.10	1.46	10.3	10.7
			30.5		15.92	1.56	10.2	10.6
			31.0	133.9	16.25	1.56	10.4	10.5
			32.6	207.2	17.57	1.54	11.4	10.2
			33.2		18.23	1.56	11.7	10.1
			33.7		18.40	1.57	11.7	10.1
			34.3	104.1	18.07	1.53	11.8	10.1
			34.8		17.41	1.61	10.8	10.1
			35.4		16.75	1.48	11.3	10.4
			35.9	192.5	14.60	1.34	10.9	10.5
			36.4		14.77	1.35	10.9	10.5
			37.0		14.93	1.35	11.1	10.6
			37.5	179.3	14.77	1.38	10.7	10.6
			38.1		13.28	1.24	10.7	10.7
			38.6		12.63	1.21	10.4	10.9
			39.2	321.1	12.13	1.17	10.4	10.9
			39.7		11.64	1.15	10.1	11.0
			40.3		10.65	1.10	9.7	11.2
			40.8	395.6	10.48	1.10	9.5	11.3
			41.3		10.15	1.08	9.4	11.3
			41.9		9.99	1.07	9.3	11.3
			42.4	426.0	10.48	1.11	9.4	11.3
			44.6	393.6	11.31	1.10	10.3	11.0
			45.2		13.94	1.24	11.2	10.9

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			45.7	230.0	15.43	1.36	11.3	10.4
2200	36 23.2	122 17.7	46.2		16.09	1.46	11.0	10.4
			46.8		15.92	1.43	11.1	10.4
			47.3	229.9	16.58	1.43	11.6	10.3
			47.9		12.46	1.20	10.4	10.5
			48.4		15.59	1.38	11.3	10.6
			49.0	290.8	15.26	1.38	11.1	10.6
			50.0	341.8	14.93	1.33	11.2	10.7
			51.1		14.60	1.31	11.1	10.7
			51.7		14.27	1.31	10.9	10.7
			52.2	266.5	14.77	1.40	10.6	10.4
			52.8		14.60	1.36	10.7	10.9
			53.6	131.8	14.77	1.34	11.0	10.8
			54.1		14.77	1.34	11.0	10.8
			54.7		14.77	1.25	11.8	10.8
			55.2		14.77	1.37	10.3	10.7
			55.8	523.5	14.93	1.31	11.4	10.7
			56.3		14.44	1.31	11.0	11.0
			56.9		13.26	1.31	10.1	11.0
			57.4	416.7	13.12	1.28	10.3	11.1
			57.9		12.63	1.25	10.1	11.1
			58.5	231.7	12.63	1.25	10.1	11.2
			65.0	209.2	7.02	0.96	7.3	11.8
			65.6		6.55	0.92	7.1	11.9
			66.1		5.36	0.92	6.9	11.9
2300	36 17.3	122 28.3	66.6	578.3	6.20	0.89	7.0	11.9
			67.2		6.20	0.89	7.0	11.9
			67.7		6.03	0.85	7.1	11.9
			68.3	307.9	5.70	0.86	6.6	11.9
			68.8		5.37	0.86	6.2	11.9
			69.4		5.21	0.83	6.3	11.9
			69.9	819.1	5.04	0.79	6.4	11.9
			71.0		4.38	0.76	5.8	12.1
			71.5	372.2	4.22	0.78	5.4	12.2
			72.1		3.89	0.72	5.4	12.2
			72.6		3.72	0.72	5.2	12.2
			73.2	389.6	3.56	0.71	5.0	12.2
			73.7		3.56	0.71	5.0	12.2
			74.3		3.39	0.72	4.7	12.2
			74.3	419.2	3.39	0.72	4.7	12.2
			75.3		3.39	0.72	4.7	12.2
			75.9	321.5	3.39	0.72	4.7	12.2
			77.0		3.23	0.72	4.5	12.2
			77.5		3.23	0.72	4.5	12.2
			78.1	266.8	3.23	0.72	4.5	12.2
2400	36 10.3	122 37.8	78.6		3.23	0.70	4.6	12.2
			79.2		3.23	0.69	4.7	12.2
			79.7	263.2	3.23	0.71	4.5	12.2
			80.2		3.39	0.69	4.9	12.2
			80.8		3.39	0.79	4.3	12.2

R/V ACANIA 8 CEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			81.3	177.2	3.39	0.79	4.3	12.2
			81.9		3.39	0.79	4.3	12.2
			87.3		3.39	0.63	5.4	12.3
			87.9	501.5	3.39	0.63	5.4	12.3
			88.4		3.39	0.64	5.3	12.3
			88.9		3.39	0.64	5.3	12.2
			89.5	382.1	3.39	0.64	5.3	12.2
			90.0		3.56	0.66	5.4	12.2
			90.6		3.72	0.67	5.5	12.1
			91.1	485.4	3.72	0.65	5.7	12.1
			91.7		3.89	0.66	5.9	12.1
			92.2		4.05	0.66	6.1	12.1
			93.3	503.0	3.72	0.67	5.6	12.2
			93.8		3.56	0.65	5.5	12.2
			94.4	1507.7	3.39	0.66	5.1	12.3
0100	36 3.3	122 47.2	94.9		3.39	0.66	5.1	12.3
			95.5		3.39	0.62	5.5	12.4
			96.6	352.3	3.56	0.65	5.5	12.4
			97.1	131.3	3.56	0.43	8.3	12.5
			97.3		0.0	0.0	0.0	12.5
			104.6		0.0	0.0	0.0	12.5
			112.5		0.0	0.0	0.0	12.4
			112.6		3.39	0.65	5.2	12.4
			113.1		3.39	0.65	5.2	12.4
			113.7		3.39	0.65	5.2	12.4
			114.3	422.0	3.39	0.66	5.1	12.4
0130	35 58.3	122 51.3	114.9		3.39	0.64	5.3	12.4
			115.5		3.39	0.65	5.2	12.3
			116.1	303.0	3.72	0.67	5.6	12.3
			116.7		3.72	0.67	5.6	12.3
0230	35 58.6	122 52.9	117.3	344.6	3.72	0.67	5.6	12.2
			119.4		4.05	0.71	5.7	12.2
			120.0		4.05	0.79	5.1	12.2
			120.6		4.05	0.72	5.6	12.2
			121.1	235.4	4.05	0.70	5.8	12.3
			121.9		3.89	0.70	5.6	12.3
			122.3		3.89	0.70	5.6	12.3
			122.9	545.5	3.72	0.70	5.3	12.3
			123.5		3.72	0.70	5.3	12.3
			124.1		3.72	0.68	5.5	12.4
			124.7	311.5	3.72	0.72	5.2	12.4
			125.3		3.72	0.69	5.4	12.5
			125.9		3.72	0.79	4.7	12.5
0300	35 56.0	122 57.4	126.5	564.5	3.89	0.79	4.9	12.5
			127.1		4.05	0.82	4.9	12.5
			127.7		4.22	0.82	5.1	12.5
			128.3	825.3	4.22	0.82	5.1	12.5
			128.9		4.22	0.81	5.2	12.5
			129.4	338.5	4.38	0.81	5.4	12.5
			130.0		4.38	0.83	5.3	12.5

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			130.6		4.38	0.84	5.2	12.5
			131.5	600.1	4.38	0.81	5.4	12.5
			132.1		4.38	0.83	5.3	12.5
			132.7		4.38	0.91	4.8	12.5
			133.3	840.8	4.55	0.74	6.1	12.5
			133.9		4.55	0.74	6.1	12.5
			134.5		4.55	0.74	6.1	12.5
			135.1		4.55	0.75	6.1	12.5
			135.7		4.55	0.73	6.2	12.5
			136.3	299.0	4.55	0.73	6.2	12.3
			138.6	573.9	3.89	0.80	4.9	12.3
			139.2		3.89	0.80	4.9	12.2
			139.8		3.89	0.80	4.9	12.2
			140.4	1040.9	3.89	0.80	4.9	12.3
			141.0		3.89	0.80	4.9	12.3
			141.6		3.89	0.80	4.9	12.3
			142.2	571.3	4.05	0.80	5.1	12.3
			142.8		4.22	0.80	5.3	12.4
0400	35 51.0	123 7.0	143.4		4.05	0.80	5.1	12.5
			144.0	572.0	4.05	0.82	4.9	12.5
			147.8		3.39	0.78	4.3	12.6
			148.4		3.56	0.78	4.6	12.5
			149.0	353.3	3.56	0.88	4.0	12.5
			149.6		3.56	0.88	4.0	12.5
			150.2		3.56	0.88	4.0	12.5
			150.8	479.9	3.56	0.85	4.2	12.5
			151.4		3.56	0.81	4.4	12.5
			154.0	554.1	3.89	0.86	4.5	12.5
			154.6	651.2	4.05	0.88	4.6	12.5
			155.2		4.05	0.83	4.9	12.6
			155.8		3.72	0.83	4.5	12.6
			156.4	794.6	3.72	0.83	4.5	12.6
			157.0		3.72	0.81	4.6	12.7
			157.6		3.72	0.81	4.6	12.7
			158.2	229.8	3.72	0.84	4.4	12.7
			158.8		3.72	0.80	4.6	12.7
			160.0	374.9	3.56	0.80	4.4	12.7
			160.6		3.72	0.80	4.6	12.7
			161.1		3.72	0.79	4.7	12.7
			161.7	560.9	3.72	0.87	4.2	12.4
0500	35 45.1	123 16.2	162.3		3.72	0.81	4.6	12.4
			162.9		3.72	0.81	4.6	12.4
			163.5	583.1	3.72	0.81	4.6	12.4
			164.1		3.72	0.81	4.6	12.6
			164.7		3.72	0.78	4.8	12.6
			165.3	668.7	3.72	0.67	5.6	12.6
			166.5		3.56	0.79	4.5	12.7
			167.1	294.4	3.56	0.79	4.5	12.7
			167.7		3.56	0.79	4.5	12.7
			168.3		3.56	0.78	4.6	12.8

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			168.9	394.7	3.56	0.84	4.2	12.8
			169.4		3.39	0.76	4.5	12.8
			170.0		3.39	0.76	4.5	12.8
			170.6	317.3	3.39	0.76	4.5	12.8
			171.2		3.39	0.76	4.5	12.8
			171.8		3.39	0.76	4.5	12.8
			172.4	251.6	3.23	0.79	4.1	12.8
			173.0		3.23	0.76	4.2	12.7
			173.6		3.23	0.78	4.1	12.7
			174.2	294.2	3.23	0.78	4.1	12.7
			174.8		3.25	0.78	4.1	12.7
			175.4		3.39	0.77	4.4	12.7
			176.0	333.3	3.39	0.77	4.4	12.7
			176.6		3.56	0.79	4.5	12.7
			177.1		3.56	0.79	4.5	12.7
			177.7	374.3	3.72	0.89	4.2	12.7
			178.9		3.39	0.78	4.3	12.7
			179.5		3.39	0.78	4.3	12.6
0600	35 39.0	123 25.3	180.1		3.39	0.78	4.3	12.6
			180.7		3.39	0.79	4.3	12.6
			181.3		3.39	0.79	4.3	12.5
			181.9	976.8	3.39	0.77	4.4	12.5
			183.1		3.23	0.78	4.1	12.5
			183.7		3.39	0.78	4.3	12.4
			184.3		3.39	0.78	4.3	12.4
			184.9		3.23	0.77	4.2	12.4
			185.4		3.39	0.79	4.3	12.4
			186.0		3.39	0.79	4.3	12.4
			186.6		3.39	0.79	4.3	12.4
			187.2		3.39	0.79	4.3	12.4
			187.8		3.39	0.79	4.3	12.4
			189.6		3.41	0.76	4.5	12.4
			190.2		3.43	0.78	4.4	12.4
			190.8		3.45	0.78	4.4	12.4
			191.4		3.47	0.75	4.6	12.4
			192.0		3.49	0.75	4.7	12.4
			192.6		3.51	0.77	4.6	12.4
			193.1		3.53	0.75	4.6	12.4
			193.7		3.57	0.74	4.8	12.4
			194.3		3.49	0.74	4.7	12.4
			195.5		3.49	0.73	4.8	12.5
			196.1		3.49	0.73	4.8	12.5
			196.7		3.44	0.71	4.8	12.5
0700	35 33.5	123 34.6	197.3		3.44	0.71	4.8	12.6
			197.9		3.39	0.71	4.8	12.6
			198.5		3.39	0.76	4.5	12.6
			199.1		3.39	0.76	4.5	12.6
			199.7		3.39	0.76	4.5	12.6
			200.3		3.39	0.67	5.1	12.6
			200.9		3.39	0.67	5.1	12.6

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TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			202.0		3.39	0.66	5.1	12.6
			202.6		3.39	0.66	5.1	12.6
			203.2		3.39	0.66	5.1	12.6
			203.8		3.39	0.66	5.1	12.6
			204.4		3.39	0.63	5.4	12.6
			205.0		3.39	0.63	5.4	12.6
			205.6		3.39	0.63	5.4	12.6
			206.2		3.39	0.63	5.4	12.6
			207.4		3.39	0.63	5.4	12.6
			209.0		3.88	0.59	6.6	12.5
0800	35 27.6	123 42.2	209.6		3.88	0.57	6.9	12.5
			210.2		3.71	0.59	6.3	12.6
			210.8		3.73	0.56	6.7	12.6
			211.4		3.75	0.58	6.5	12.6
			212.0		3.77	0.56	6.7	12.6
			212.6		3.58	0.54	6.6	12.6
			213.2		3.80	0.53	7.2	12.6
			214.4		3.43	0.53	6.5	12.6
			215.0		3.43	0.53	6.5	12.6
			215.6		3.67	0.52	7.1	12.6
			216.2		3.69	0.52	7.1	12.6
			216.8		3.70	0.52	7.1	12.6
			217.4		3.72	0.51	7.3	12.6
			218.0		3.74	0.51	7.3	12.6
			218.6		3.74	0.51	7.3	12.6
			219.2		3.74	0.51	7.3	12.6
			219.8		3.79	0.50	7.6	12.6
			221.0		3.82	0.50	7.6	12.5
			221.6		3.84	0.48	8.0	12.5
			222.2		3.86	0.47	8.2	12.5
			222.8		3.66	0.47	7.8	12.4
			223.4		3.66	0.47	7.8	12.4
			224.0		3.69	0.50	7.4	12.4
			224.6		3.93	0.50	7.9	12.4
			225.2		3.72	0.48	7.7	12.4
			225.8		3.72	0.48	7.7	12.4
			226.4		3.72	0.48	7.7	12.4
0900	35 31.3	123 34.0	232.9		3.69	0.84	4.4	12.3
			233.5		3.71	0.82	4.5	12.3
			234.1		3.71	0.82	4.5	12.3
			234.7		3.74	0.81	4.6	12.3
			235.9		3.77	0.79	4.8	12.4
			236.5		3.54	0.79	4.5	12.4
			237.1		3.56	0.77	4.6	12.5
			237.7		3.57	0.77	4.6	12.5
			238.3		3.59	0.77	4.7	12.5
			239.5		3.62	0.77	4.7	12.5
			240.1		3.63	0.78	4.7	12.6
			240.7		3.63	0.78	4.7	12.6
			241.3		3.66	0.78	4.7	12.7

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			241.9		3.66	0.78	4.7	12.7
			242.5		3.94	0.78	5.1	12.7
			243.1		3.95	0.80	4.9	12.7
			243.7		3.95	0.80	4.9	12.7
			244.3		3.73	0.79	4.7	12.7
			244.9		3.73	0.79	4.7	12.7
1000	35 39.1	123 25.6	246.1		3.52	0.75	4.7	12.7
			246.7		3.52	0.75	4.7	12.7
			247.3		3.52	0.75	4.7	12.7
			247.9		3.56	0.77	4.6	12.7
			248.5		3.83	0.77	5.0	12.7
			249.1		3.84	0.76	5.1	12.7
			249.7		3.84	0.76	5.1	12.7
			250.3		3.84	0.76	5.1	12.7
			250.9		3.84	0.76	5.1	12.7
			251.5		3.84	0.76	5.1	12.7
			252.7		3.93	0.76	5.2	12.6
			253.3		3.93	0.76	5.2	12.6
			253.9		4.23	0.77	5.5	12.6
			254.5		4.24	0.77	5.5	12.6
			255.1		4.26	0.79	5.4	12.7
			255.7		4.26	0.77	5.5	12.7
			256.3		4.29	0.77	5.6	12.7
			256.9		4.30	0.81	5.3	12.7
			257.5		4.32	0.77	5.6	12.6
			258.1		4.33	0.79	5.5	12.6
			259.3		4.36	0.79	5.5	12.6
			259.9		4.36	0.79	5.5	12.6
			260.5		4.36	0.79	5.5	12.6
			261.1		4.36	0.79	5.5	12.6
			261.7		4.42	0.76	5.8	12.6
			262.3		4.44	0.78	5.7	12.5
			262.9		4.44	0.78	5.7	12.5
			263.5		4.44	0.78	5.7	12.5
			264.1		4.48	0.79	5.7	12.5
			264.7		4.79	0.79	6.1	12.4
			265.3		4.52	0.79	5.7	12.4
1100	35 42.8	123 20.9	265.9		4.52	0.79	5.7	12.4
			266.5		4.52	0.79	5.7	12.4
			267.7		4.58	0.77	5.9	12.4
			271.9		4.09	0.78	5.2	12.5
			272.4		4.09	0.78	5.2	12.5
			273.0		4.12	0.78	5.3	12.5
			273.6		4.12	0.78	5.3	12.5
			274.2		4.14	0.77	5.4	12.5
			274.8		4.46	0.83	5.4	12.4
			275.4		4.17	0.79	5.3	12.4
			276.0		4.17	0.77	5.4	12.4
			276.6		4.20	0.77	5.5	12.3
			277.2		4.21	0.76	5.5	12.3

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			278.4		4.24	0.76	5.6	12.3
			279.0		4.24	0.76	5.6	12.3
			279.6		4.24	0.76	5.6	12.3
			280.2		4.27	0.80	5.3	12.4
			280.8		4.29	0.76	5.6	12.4
			281.4		4.29	0.76	5.6	12.4
			282.0		4.29	0.76	5.6	12.4
			282.6		4.33	0.77	5.6	12.4
			283.2		4.34	0.78	5.6	12.4
			283.8		4.35	0.79	5.5	12.4
			285.0		4.38	0.75	5.8	12.4
			285.6		4.39	0.77	5.7	12.4
1200	35 50.7	123 5.4	286.2		4.39	0.77	5.7	12.4
			286.8		4.39	0.77	5.7	12.4
			287.4		4.39	0.77	5.7	12.4
			288.0		4.45	0.75	5.9	12.4
			288.6		4.46	0.76	5.9	12.4
			289.2		4.46	0.76	5.9	12.4
			289.8		4.49	0.78	5.8	12.3
			290.4		4.49	0.73	5.8	12.3
			291.6		4.20	0.74	5.7	12.3
			292.2		3.88	0.74	5.2	12.3
			292.8		3.88	0.74	5.2	12.3
			293.4		3.91	0.73	5.4	12.3
			294.0		3.91	0.73	5.4	12.2
			294.6		3.60	0.73	4.9	12.2
			295.2		3.49	0.73	4.8	12.1
			295.8		3.49	0.73	4.8	12.1
			296.4		4.30	0.75	5.7	12.2
			297.0		4.65	0.77	6.0	12.2
			298.2		5.01	0.81	6.2	12.1
			298.8		4.69	0.78	6.0	12.0
			299.4		4.69	0.78	6.0	12.0
			300.0		4.71	0.76	6.2	12.1
			300.6		4.38	0.74	5.9	12.1
			301.2		4.38	0.74	5.9	12.1
			301.8		4.06	0.74	5.5	12.1
			302.4		4.06	0.74	5.5	12.1
			303.0		4.09	0.75	5.5	12.1
1300	35 56.5	122 55.3	303.6		4.10	0.73	5.6	12.2
			307.2		3.81	0.77	4.9	12.2
			307.8		3.83	0.72	5.3	12.2
			308.4		3.83	0.72	5.3	12.2
			309.0		3.83	0.72	5.3	12.2
			309.6		3.83	0.72	5.3	12.2
			310.2		3.87	0.70	5.5	12.1
			310.8		3.87	0.70	5.5	12.1
			311.4		3.87	0.70	5.5	12.0
			312.0		3.90	0.72	5.4	12.0
			312.6		3.91	0.72	5.4	12.0

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			313.8		4.29	0.73	5.9	12.0
			314.4		4.29	0.73	5.9	12.0
			314.9		4.29	0.73	5.9	12.0
			315.5		4.69	0.73	6.4	12.0
			316.1		4.34	0.73	5.9	12.1
			316.7		4.35	0.71	6.1	12.1
			317.3		3.99	0.71	5.6	12.1
			317.9		4.37	0.74	5.9	12.1
			318.5		4.76	0.72	6.6	12.1
			319.1		3.65	0.72	5.1	12.2
			321.2		3.65	0.72	5.1	12.2
			321.8		3.32	0.70	4.7	12.2
			322.4		3.33	0.72	4.6	12.2
1400	36 2.6	122 45.9	323.0		3.34	0.71	4.7	12.2
			323.6		3.34	0.75	4.5	12.1
			324.2		3.35	0.71	4.7	12.1
			324.8		3.35	0.71	4.7	12.1
			325.4		3.35	0.71	4.7	12.1
			327.2		3.40	0.72	4.7	12.1
			327.8		3.02	0.72	4.2	12.1
			328.4		2.64	0.70	3.8	12.1
			329.0		2.64	0.70	3.8	12.1
			335.9		4.33	0.79	5.5	12.0
			336.5		3.99	0.75	5.3	12.0
			337.1		3.99	0.75	5.3	12.0
			337.7		4.16	0.75	5.5	11.9
			338.3		4.33	0.73	5.9	11.9
			338.9		4.49	0.73	6.2	11.9
			339.5		4.66	0.76	6.1	11.8
			340.1		4.83	0.86	5.6	11.7
1500	36 8.4	122 36.6	340.7		4.99	0.78	6.4	11.7
			341.3		6.33	0.86	7.4	11.7
			341.9		6.16	0.84	7.3	11.7
			343.1		7.16	0.92	7.8	11.6
			343.7		7.33	0.90	8.1	11.6
			344.3		7.49	0.92	8.1	11.5
			344.9		7.66	0.92	8.3	11.4
			345.5		8.33	0.96	8.7	11.3
			346.1		8.99	1.00	9.0	11.2
			346.7		9.66	1.03	9.4	11.1
			347.3		10.33	1.07	9.7	11.1
			347.9		10.83	1.11	9.8	11.0
			349.1		11.33	1.13	10.0	11.0
			349.7		11.16	1.13	9.9	11.0
			350.3		11.16	1.13	9.9	11.0
			350.9		11.49	1.13	10.2	10.9
			351.5		11.99	1.15	10.4	11.0
			352.1		12.49	1.23	10.2	11.1
			352.7		10.99	1.14	9.6	11.2
			353.3		10.83	1.16	9.3	11.3

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			353.9		10.16	1.06	9.6	11.3
			354.5		10.16	1.06	9.6	11.4
			355.7		9.49	1.04	9.1	11.5
			356.3		9.66	1.04	9.3	11.5
			356.8		9.33	1.03	9.1	11.5
			357.4		9.16	1.01	9.1	11.7
			358.0		8.99	1.01	8.9	11.7
1600	36 14.3	122 26.7	358.6		8.66	0.97	8.9	11.9
			362.5		7.99	0.92	8.7	11.9
			363.1		7.83	0.90	8.7	11.9
			363.7		7.83	0.90	8.7	11.9
			364.3		7.83	0.90	8.7	11.8
			364.9		7.83	0.90	8.7	11.8
			365.5		7.99	0.92	8.7	11.8
			366.1		7.99	0.92	8.7	11.7
			366.7		8.33	0.94	8.9	11.4
			367.9		9.99	1.02	9.8	11.2
			368.5		10.16	1.02	10.0	11.0
			369.1		11.33	1.10	10.3	10.8
			369.7		14.99	1.30	11.5	10.6
			370.3		15.33	1.32	11.6	10.4
			370.9		15.66	1.34	11.7	10.2
			371.5		17.16	1.44	11.9	10.2
			372.1		17.83	1.46	12.2	10.1
			372.7		17.99	1.48	12.2	10.1
			373.3		18.16	1.49	12.2	10.1
			374.5		17.66	1.45	12.2	10.2
			375.1		17.93	1.45	12.4	10.2
			375.7		17.83	1.45	12.3	10.2
1700	36 21.7	122 18.3	376.3		17.93	1.47	12.2	10.1
			376.9		17.63	1.45	12.3	10.1
			377.5		17.83	1.45	12.3	10.1
			378.1		17.66	1.45	12.2	10.1
			378.7		17.49	1.48	11.8	10.1
			379.3		17.33	1.42	12.2	10.5
			381.1		17.33	1.48	11.7	10.6
			381.7		16.49	1.46	11.3	10.6
			382.3		16.66	1.46	11.4	10.6
			382.9		16.66	1.46	11.4	10.6
			383.5		16.83	1.41	11.9	10.6
			384.1		16.66	1.49	11.2	10.5
			384.7		17.16	1.49	11.5	10.7
			385.3		16.83	1.47	11.4	10.9
			385.9		16.33	1.51	10.8	10.9
			386.5		15.66	1.47	10.7	10.9
			387.7		15.16	1.67	9.1	10.9
			388.3		15.16	1.69	9.0	10.8
			388.9		15.33	1.65	9.3	10.8
			389.5		15.33	1.65	9.3	10.3
			390.1		15.16	1.66	9.1	10.8

R/V ACANIA 8 DEC 78 CHEMICAL MESOSCALE(CRUISE III)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			390.7		15.16	1.66	9.1	10.9
			391.3		15.33	1.69	9.1	10.8
			391.9		15.33	1.68	9.1	10.9
			392.5		15.66	1.74	9.0	10.8
			393.1		15.99	1.78	9.0	10.8
1800	36 28.5	122 10.2	394.3		15.83	1.74	9.1	10.7
			394.9		16.16	1.76	9.2	10.7
			395.5		16.49	1.77	9.3	10.7
			396.1		15.99	1.79	8.9	10.7
			396.7		16.33	1.79	9.1	10.7
			397.3		16.33	1.79	9.1	10.7
			397.9		16.16	1.77	9.1	10.8
			398.5		15.83	1.75	9.0	10.8
			399.0		15.83	1.75	9.0	10.8
			399.6		15.83	1.66	9.5	10.7
			400.8		15.99	1.66	9.6	10.7
			401.4		16.16	1.66	9.7	10.7
			402.0		16.09	1.51	10.7	10.7
			402.6		16.39	1.49	11.0	10.7
			403.2		16.39	1.53	10.7	10.7
			403.8		16.69	1.53	10.9	10.5
			404.4		16.54	1.60	10.3	10.2
			405.0		17.59	1.70	10.3	9.9
			405.6		19.25	1.85	10.4	9.7
			406.2		21.55	1.85	11.6	9.6
			406.8		22.11	1.89	11.7	9.6
			407.4		22.41	1.93	11.6	9.6
			408.6		23.16	1.89	12.3	9.7
			409.8		22.11	1.89	11.7	9.9
			410.4		22.11	1.87	11.8	10.0
			411.0		21.65	1.81	12.0	10.1
			411.6		21.36	1.78	12.0	10.2
			412.2		20.45	1.81	11.3	10.3
1900	36 34.9	122 1.5	412.8		20.55	1.72	11.9	10.4
			413.4		19.40	1.70	11.4	10.5
			414.0		19.10	1.72	11.1	10.6
			415.2		19.10	1.72	11.1	10.7
			415.8		18.79	1.63	11.2	10.8

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
1442	36 38.3	121 57.5	0.0		3.51	0.70	5.0	12.4
			0.6		3.67	0.60	6.1	12.4
			1.1		3.82	0.63	6.1	12.4
			1.7		3.82	0.66	5.8	12.4
			2.3		3.82	0.66	5.8	12.4
			2.9		3.82	0.64	6.0	12.4
			3.4	950.2	3.67	0.66	5.6	12.4
			4.6		3.82	0.69	5.5	12.4
1500	36 36.8	121 59.6	5.2	370.5	4.14	0.61	5.1	12.5
			6.3		3.98	0.70	5.7	12.5
			6.9	338.6	3.82	0.70	5.5	12.5
			7.5		3.82	0.68	5.6	12.5
			8.0		3.67	0.68	5.4	12.5
			8.6	555.5	3.67	0.66	5.6	12.5
			9.2		3.51	0.83	4.2	12.5
			9.8		3.51	0.71	4.9	12.5
			10.3	659.1	3.51	0.64	5.5	12.5
			10.9		3.51	0.64	5.5	12.5
			11.5	1054.9	3.51	0.71	4.9	12.5
			12.6		3.35	0.64	5.2	12.5
			13.2		3.51	0.65	5.4	12.5
			13.8	466.1	3.67	0.67	5.5	12.5
			14.3		3.67	0.65	5.6	12.5
			14.9		3.51	0.65	5.4	12.5
			15.5	610.7	3.67	0.65	5.6	12.4
			16.1		3.82	0.66	5.8	12.4
			16.6		3.67	0.66	5.6	12.4
			17.2	515.6	3.67	0.66	5.6	12.4
			17.8		3.51	0.66	5.3	12.4
			18.9	694.4	3.51	0.64	5.5	12.4
			19.5		3.51	0.74	4.7	12.4
			20.1		3.51	0.67	5.2	12.4
			20.7	705.6	3.67	0.70	5.2	12.4
			21.2		3.67	0.67	5.5	12.4
			21.8		3.82	0.72	5.3	12.4
1600	36 29.7	122 7.6	22.4	784.2	3.98	0.70	5.7	12.3
			23.0		3.98	0.75	5.3	12.3
			23.5		3.98	0.71	5.6	12.3
			24.1	715.9	3.98	0.68	5.9	12.3
			28.7	905.2	3.98	0.60	6.6	12.2
			29.3	845.5	3.98	0.61	6.5	12.2
			29.8		3.98	0.61	6.5	12.2
			30.4		3.98	0.61	6.5	12.2
			31.0	605.3	3.82	0.61	6.3	12.2
			32.1		3.67	0.58	6.3	12.3
			32.7	987.8	3.67	0.56	6.6	12.3
			33.3		3.67	0.59	6.2	12.3
			33.9		3.51	0.59	5.9	12.4
			34.4	912.0	3.35	0.56	6.0	12.4
			35.0		3.33	0.56	5.9	12.4

R/V ACANIA 20 JAN 79 CHEMICAL MESOSCALE(CRUISE IV)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			35.6		3.35	0.56	6.0	12.5
			36.2	444.3	3.35	0.57	5.9	12.5
			36.7		3.19	0.57	5.6	12.5
			37.3	482.5	3.03	0.57	5.3	12.5
			38.5		2.87	0.54	5.3	12.6
1700	36 22.0	122 14.6	39.6	424.9	2.71	0.50	5.4	12.7
			40.2		2.87	0.52	5.5	12.7
			40.8		2.87	0.52	5.5	12.7
			41.3	500.4	3.03	0.52	5.8	12.7
			41.9		3.19	0.55	5.8	12.7
			42.5		3.19	0.55	5.8	12.7
			43.0	567.3	3.19	0.55	5.8	12.6
			44.8	499.8	3.03	0.58	5.2	12.6
			45.3		3.03	0.55	5.5	12.6
			45.9		3.03	0.55	5.5	12.6
			46.5	553.4	2.87	0.51	5.6	12.7
			47.1		2.87	0.51	5.6	12.7
			47.6		2.71	0.51	5.3	12.7
			48.2	548.1	2.71	0.48	5.6	12.7
			48.8		2.55	0.48	5.3	12.7
			49.4		2.55	0.49	5.2	12.8
			49.9	1165.3	2.55	0.49	5.2	12.8
			50.5		2.55	0.46	5.5	12.8
			51.1		2.39	0.46	5.2	12.8
			51.7	465.9	2.39	0.46	5.2	12.8
			52.8		2.55	0.44	5.8	12.8
			53.4		2.55	0.47	5.4	12.8
			54.0		2.55	0.47	5.4	12.8
			54.5		2.55	0.47	5.4	12.8
			55.1		2.55	0.47	5.4	12.8
			55.7		2.71	0.49	5.5	12.8
			56.3		2.55	0.45	5.7	12.8
1800	36 13.8	122 20.2	56.8		2.55	0.45	5.7	12.8
			57.4		2.55	0.45	5.7	12.8
			58.0	589.9	2.55	0.45	5.7	12.8
			59.1		2.55	0.43	5.9	12.8
			59.7		2.55	0.43	5.9	12.8
			60.3	494.5	2.55	0.43	5.9	12.8
			60.8		2.55	0.43	5.9	12.8
			61.4		2.55	0.45	5.7	12.8
			62.0	592.1	2.55	0.45	5.7	12.8
			62.6		2.55	0.45	5.7	12.8
			63.1		2.55	0.43	5.9	12.8
			63.7	601.5	2.71	0.43	6.3	12.8
			64.3		2.71	0.46	5.9	12.8
			64.9	552.9	2.87	0.55	5.2	12.8
			67.7	607.7	2.71	0.53	5.1	12.8
			68.3		2.71	0.49	5.5	12.8
			68.9		2.87	0.49	5.9	12.8
			69.5		3.03	0.49	6.2	12.7

R/V ACANIA 20 JAN 79 CHEMICAL MESOSCALE(CRUISE IV)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			70.0		3.10	0.49	6.3	12.7
			70.6	872.9	2.95	0.49	6.0	12.7
			71.2		2.96	0.46	6.4	12.7
			71.7		2.97	0.45	6.6	12.7
			72.3	983.6	2.81	0.45	6.2	12.7
			72.9		2.98	0.44	6.8	12.7
1900	36 5.0	122 25.5	74.0	941.4	3.00	0.44	6.8	12.7
			74.6		3.01	0.42	7.2	12.7
			75.2		3.02	0.45	6.7	12.7
			75.8	973.2	3.02	0.42	7.2	12.7
			76.3		2.87	0.42	6.8	12.7
			76.9		2.88	0.42	6.9	12.7
			77.5	1385.8	2.89	0.42	6.9	12.7
			78.1		2.90	0.43	6.7	12.7
			78.6		2.91	0.43	6.8	12.7
			79.2	1321.7	2.91	0.43	6.9	12.7
			80.4		3.09	0.40	7.7	12.7
			80.9	827.1	3.10	0.43	7.2	12.8
			81.5		2.95	0.41	7.2	12.9
			82.1		2.79	0.41	6.8	12.9
			82.7	721.0	2.64	0.41	6.4	12.9
			83.2		2.65	0.33	7.0	12.9
			83.8		2.66	0.51	5.2	12.8
			84.4	673.1	2.67	0.38	7.0	12.7
			85.0		2.67	0.39	6.9	12.7
			85.5	798.3	2.68	0.39	6.9	12.7
			86.7		2.54	0.36	7.1	12.7
			87.2	414.7	2.55	0.36	7.1	12.7
			87.8		2.55	0.36	7.1	12.7
			88.4		2.56	0.37	6.9	12.6
			89.0	571.9	2.57	0.37	6.9	12.6
			89.5		2.58	0.39	6.6	12.6
			90.1		2.75	0.37	7.4	12.6
			90.7	670.4	2.92	0.39	7.5	12.6
2000	35 57.1	122 31.8	91.3		3.09	0.39	7.9	12.6
			92.4		3.27	0.42	7.8	12.6
			93.0	713.3	3.27	0.40	8.2	12.6
			93.6		3.44	0.40	8.6	12.6
			94.1		3.45	0.40	8.6	12.6
			94.7	739.9	3.46	0.42	8.2	12.6
			95.3		3.47	0.42	8.3	12.6
			95.9		3.64	0.42	8.7	12.6
			96.4	864.7	3.65	0.45	8.1	12.6
			97.0		3.65	0.45	8.1	12.6
			97.6	783.3	3.50	0.45	7.8	12.6
			101.6	1228.4	3.51	0.50	7.0	12.5
			102.2		3.71	0.48	7.7	12.5
			102.7		3.76	0.46	8.2	12.4
			103.3	1133.5	3.80	0.46	8.3	12.3
			103.9		3.68	0.46	8.0	12.1

R/V ACANIA 20 JAN 79 CHEMICAL MESOSCALE(CRUISE IV)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NITR.RATIO NO3/PO4	TEMP DEG C
			104.5	1167.1	3.72	0.43	8.7	11.9
			105.6		4.09	0.46	8.9	11.9
			106.2		4.09	0.45	8.9	11.8
			106.8		4.26	0.46	9.3	11.8
			107.3		4.26	0.44	9.7	11.8
2100	35 49.0	122 37.8	107.9		4.26	0.46	9.3	11.8
			108.5	1105.8	4.44	0.47	9.4	11.8
			109.6		4.59	0.47	9.8	11.8
			110.2	1732.4	4.59	0.49	9.4	11.8
			113.1		5.24	0.45	11.6	11.8
			113.7	1056.7	5.24	0.45	11.6	11.8
			115.4	1312.6	4.91	0.50	9.9	11.8
			115.9		4.91	0.50	9.9	11.8
			116.5		4.91	0.50	9.8	11.8
			117.1	1528.7	4.59	0.50	9.2	11.8
			117.7	1546.8	4.59	0.53	8.7	11.8
			118.8		4.59	0.48	9.6	11.8
			120.0	1436.5	4.59	0.55	8.3	11.8
			120.5		4.59	0.50	9.2	11.8
			121.1	1059.0	4.59	0.51	9.0	11.8
			122.3		4.75	0.56	8.5	11.9
			122.8		4.59	0.51	9.0	11.8
2200	35 40.8	122 44.1	123.4		4.59	0.51	9.0	11.8
			124.0		4.59	0.51	9.0	11.9
			124.6		4.75	0.53	9.0	11.9
			125.1	618.6	4.59	0.54	8.5	11.9
			125.7		4.75	0.51	9.3	11.9
			126.9		4.59	0.49	9.4	11.9
			127.4	661.9	4.75	0.49	9.7	11.9
			128.0		4.59	0.49	9.4	11.9
			128.6	644.3	4.59	0.49	9.4	11.9
			129.1		4.59	0.49	9.4	11.9
			129.7		4.75	0.54	8.8	11.9
			130.3	573.7	4.75	0.49	9.7	11.9
			130.9		4.75	0.52	9.1	11.9
			131.4	542.3	4.75	0.52	9.1	11.9
2230	35 36.0	122 49.0	133.7	529.5	4.91	0.47	10.4	11.9
			134.3		4.91	0.52	9.4	11.9
			134.9		4.91	0.52	9.4	11.9
			135.5		4.91	0.50	9.8	11.9
			136.0	587.5	5.03	0.75	6.7	11.9
			136.3		4.88	0.65	7.5	11.9
			136.6	511.2	4.74	0.62	7.6	11.9
			137.2		4.74	0.60	7.9	11.9
			137.5		4.74	0.60	7.9	11.9
			137.8	606.4	4.74	0.60	7.9	11.9
			138.1		4.74	0.60	7.9	11.9
			138.4		4.74	0.60	7.9	11.9
			138.8	584.8	4.74	0.62	7.6	11.9
2300	35 38.4	122 48.3	139.1		4.74	0.62	7.6	11.9

R/V ACANIA 20 JAN 79 CHEMICAL MESOSCALE(CRUISE IV)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			139.4		4.74	0.60	7.9	11.9
			139.7	661.4	4.74	0.65	7.3	11.9
			140.0		4.74	0.67	7.1	11.9
			140.3		4.74	0.65	7.3	11.9
			140.6		4.74	0.62	7.6	11.9
			140.9		4.74	0.60	7.9	11.9
			141.2	512.8	4.74	0.60	7.9	11.9
			141.5		4.88	0.75	6.5	11.9
			141.9		4.59	0.58	7.9	11.9
			142.2	533.9	4.59	0.60	7.6	11.9
			142.7		4.74	0.60	7.9	11.9
			143.3		4.45	0.60	7.4	11.9
			143.9	587.8	4.31	0.58	7.4	11.9
			144.5		4.31	0.58	7.4	11.9
2400	35 43.5	122 48.6	145.1		4.31	0.60	7.2	11.9
			145.7	645.1	4.31	0.58	7.4	11.8
			146.3		4.31	0.58	7.4	11.8
			147.5	643.1	4.45	0.60	7.4	11.8
			148.1		4.45	0.60	7.4	11.8
			148.6		4.45	0.58	7.7	11.8
			149.2	884.7	4.31	0.58	7.4	11.8
			149.8		4.31	0.56	7.7	11.8
			150.4		4.31	0.59	7.3	11.8
			151.0	939.6	4.31	0.56	7.7	11.8
			151.6		4.16	0.54	7.7	11.8
			152.2		4.16	0.54	7.7	11.7
			152.8	708.1	4.02	0.55	7.3	11.7
			153.4		4.02	0.55	7.3	11.7
			154.0	865.6	4.02	0.55	7.3	11.7
			155.1		4.31	0.58	7.4	12.0
			155.7		4.16	0.56	7.4	12.2
			156.3	734.8	4.16	0.56	7.4	12.4
0100	35 43.3	122 36.7	156.9		4.02	0.58	6.9	12.4
			157.5		4.02	0.56	7.2	12.5
			158.1	660.0	3.87	0.54	7.2	12.5
			158.7		3.73	0.54	6.9	12.6
			159.3		3.73	0.54	6.9	12.7
			159.9	602.1	3.73	0.52	7.2	12.7
			160.4		3.73	0.57	6.5	12.9
			161.0	523.6	3.58	0.55	6.5	12.9
			164.0	541.6	2.86	0.56	5.1	12.9
			164.6		2.71	0.56	4.8	12.9
			165.2	569.0	2.43	0.49	5.0	12.9
			165.8		2.28	0.49	4.7	12.9
			166.3		2.28	0.52	4.4	12.9
			166.9	564.3	2.28	0.50	4.6	12.9
			167.5		2.14	0.47	4.6	12.9
			168.1		2.28	0.50	4.6	12.9
			168.7	370.8	2.14	0.48	4.5	12.9
			169.3		2.28	0.48	4.7	12.9

R/V ACANIA 20 JAN 79 CHEMICAL MESOSCALE(CRUISE IV)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			170.5	395.8	2.28	0.48	4.7	12.9
			171.1		2.28	0.49	4.7	12.9
			171.7		2.28	0.49	4.7	12.9
			172.2	401.2	2.28	0.49	4.7	12.9
			172.8		2.43	0.54	4.5	12.9
			173.4		2.28	0.52	4.4	12.9
			174.0	456.1	2.28	0.50	4.6	12.9
			174.6		2.28	0.50	4.6	12.9
			175.2		2.43	0.53	4.6	12.9
			175.8	450.2	2.43	0.50	4.9	12.9
0200	35 44.3	122 24.6	178.1	427.6	2.43	0.56	4.3	12.9
			178.7	424.5	2.43	0.54	4.5	12.9

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR. RATIO NO3/PO4	TEMP DEG C
1806	36 38.3	121 57.5	0.0		1.42	0.73	1.9	12.3
			0.5		1.42	0.73	1.9	12.3
			1.0		1.89	0.74	2.6	12.2
			1.5		2.36	0.78	3.0	12.2
			2.0		2.98	0.79	3.3	12.1
			2.6		2.28	0.73	3.1	12.1
			3.1		3.68	0.82	4.5	12.1
			6.1		5.32	1.06	5.0	11.9
			6.7		6.10	1.00	6.1	11.9
			7.2		7.19	1.03	7.0	11.8
			8.2		7.50	1.09	6.9	11.7
			9.2		6.10	1.13	5.4	11.6
			9.7		5.48	1.24	4.4	11.5
			10.2		5.94	1.07	5.6	11.5
			10.8		6.26	1.11	5.6	11.6
			11.3		5.48	1.09	5.0	11.6
			11.8		6.96	1.04	6.7	11.5
			12.3		8.59	1.13	7.2	11.4
			12.8		9.06	1.27	7.1	11.3
			13.3		8.59	1.29	6.7	11.2
			14.3		6.57	1.33	4.9	11.3
1900	36 31.6	121 59.5	14.9		6.10	1.19	5.1	11.4
			15.4		5.16	1.03	5.0	11.5
			15.9		4.23	0.92	4.6	11.6
			16.4		3.61	0.86	4.2	11.7
			16.9		3.68	0.91	4.0	11.7
			17.4		3.53	0.86	4.1	11.7
			17.9		3.76	0.86	4.4	11.7
			18.4		3.61	0.87	4.1	11.7
			19.5		3.92	0.91	4.3	11.7
			20.0		3.76	0.91	4.1	11.7
			20.5		3.61	0.88	4.1	11.7
			21.0		3.61	0.88	4.1	11.7
			21.5		3.61	0.91	4.0	11.7
			22.0		4.15	0.94	4.4	11.6
			22.5		4.38	0.95	4.6	11.7
			23.0		5.01	1.01	5.1	11.7
			24.6		5.16	0.98	5.3	11.6
			25.1		4.54	0.96	4.7	11.6
			25.6		5.94	0.96	6.2	11.6
			26.1		4.62	0.98	4.7	11.6
			26.6		4.77	0.98	4.9	11.6
			27.1		5.01	0.98	5.1	11.6
			27.7		5.32	1.03	5.2	11.6
			28.2		6.10	1.07	5.7	11.5
2 0	36 23.8	121 59.2	30.2		9.28	1.54	5.4	11.4
			30.7		8.52	1.40	6.1	11.4
			31.2		8.75	1.37	6.4	11.4
			31.3		8.59	1.32	6.5	11.4
			32.3		8.44	1.30	6.5	11.4

R/V ACANIA 26 MAR 79 CHEMICAL MESOSCALE(CRUISE V)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG C
			32.8		8.13	1.27	6.4	11.4
			33.3		9.20	1.25	6.6	11.5
			33.8		8.15	1.25	6.5	11.5
			35.8		7.89	1.35	5.8	11.5
			36.4		7.03	1.31	5.4	11.5
			36.9		5.94	1.19	5.0	11.6
			37.4		6.38	1.13	6.1	11.6
			37.9		5.40	1.25	4.3	11.6
			38.4		5.79	1.05	5.5	11.6
			38.9		5.01	1.31	3.3	11.7
			39.4		5.94	1.29	4.6	11.7
			39.9		5.24	1.23	4.3	11.7
			40.5		6.41	1.20	5.3	11.7
			41.0		6.88	1.15	6.0	11.7
			43.0		6.86	1.06	6.5	11.6
			43.5		7.35	1.12	6.5	11.6
			44.0		6.72	1.09	6.2	11.7
			44.6		6.26	1.07	5.9	11.7
2100	36 16.4	121 58.0	45.1		6.10	1.04	5.9	11.7
			45.6		6.33	1.05	6.0	11.5
			46.1		6.49	1.06	6.1	11.6
			46.6		6.57	1.07	6.1	11.5
			47.1		6.57	1.07	6.1	11.5
			47.6		7.19	1.12	6.4	11.5
			48.1		6.72	1.07	6.3	11.6
			49.2		5.94	0.99	6.0	11.7
			49.7		5.32	0.99	5.4	11.7
			50.2		5.16	0.96	5.4	11.7
			50.7		4.67	0.93	5.0	11.7
			51.2		4.15	0.93	4.5	11.7
			51.8		4.07	0.90	4.5	11.7
			52.3		4.70	0.94	5.0	11.7
			52.9		5.79	0.97	6.0	11.7
			53.5		6.08	1.05	6.6	11.6
			54.1		7.74	1.09	7.1	11.5
			54.6		7.03	1.05	6.7	11.5
			55.3		5.94	0.94	6.3	11.4
			56.3		5.97	0.92	6.4	11.5
			56.9		5.94	1.03	5.8	11.6
			57.5		6.10	0.99	6.2	11.7
			58.0		7.35	1.12	6.6	11.4
			58.6		7.50	1.08	6.9	11.7
			59.2		7.81	1.14	6.9	11.5
			59.7		8.13	1.12	7.3	11.3
			60.3		9.68	1.23	7.9	11.2
2200	36 18.1	121 56.9	61.5		11.40	1.34	8.5	11.1
			62.0		12.10	1.41	8.6	11.0
			62.6		8.59	1.19	7.2	11.0
			63.2		8.13	1.15	7.1	11.4
			63.7		8.90	1.19	7.5	11.5

R/V ACANIA 26 MAR 79 CHEMICAL MESOSCALE(CRUISE V)

TIME GMT	LATITUDE NORTH	LONGITUDE WEST	DISTANCE KM	ATP NG/L	NO3 UM/KG	PO4 UM/KG	NUTR.RATIO NO3/PO4	TEMP DEG. C
			64.3		9.55	1.33	7.1	11.5
			64.9		9.68	1.24	7.3	11.4
			65.4		10.15	1.28	7.9	11.4
			66.0		10.00	1.29	7.8	11.3
			66.6		10.62	1.35	7.9	11.3
			67.1		11.01	1.34	8.2	11.2
			67.7		10.62	1.31	8.1	11.2
			70.0		10.07	1.44	7.0	11.2
			70.6		10.31	1.36	7.6	11.2
			71.1		10.31	1.36	7.6	11.2
			71.7		10.00	1.31	7.6	11.2
			72.3		10.00	1.31	7.6	11.2
			72.8		9.59	1.22	7.9	11.2
			73.4		8.13	1.20	6.9	11.3
			74.0		6.72	1.11	6.1	11.4
			74.5		6.26	1.02	6.1	11.5
			75.1		4.77	0.95	5.0	11.5
			75.7		4.38	0.90	4.9	11.6
			76.2		4.07	0.87	4.7	11.5
			76.8		3.61	0.82	4.4	11.6
			77.4		3.29	0.78	4.2	11.7
2300	36 27.8	121 58.9	78.5		3.14	0.80	3.9	11.7
			79.1		3.45	0.82	4.2	11.7
			79.7		3.29	0.80	4.1	11.7
			80.2		2.83	0.73	3.9	11.8
			80.8		2.51	0.70	3.6	11.9
			81.4		2.12	0.73	2.9	11.9
			81.9		2.05	0.71	2.9	11.9
			82.5		2.28	0.69	3.3	11.9
			83.1		2.12	0.70	3.0	11.9
			83.6		2.05	0.69	3.0	11.7
			84.2		2.20	0.67	3.2	11.8
			84.8		2.20	0.70	3.1	11.9
			85.9		1.53	0.63	2.5	11.8
			86.5		1.19	0.60	2.0	11.8
			87.1		1.27	0.62	2.0	11.3
			87.6		1.11	0.58	1.9	11.3
			88.2		1.11	0.58	1.9	11.9
			88.8		1.27	0.58	2.2	11.8
			89.3		1.35	0.60	2.2	11.9
			89.9		1.27	0.58	2.2	11.9
			90.5		1.35	0.58	2.3	12.0
			91.0		1.74	0.63	2.8	12.0
			91.6		2.02	0.65	3.1	12.1
			92.2		2.20	0.69	3.2	12.2
			92.8		2.28	0.68	3.4	12.2
			93.3		2.28	0.65	3.5	12.3
2356	36 35.4	121 59.7	93.9		2.36	0.67	3.5	12.3

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